The great societal transformations: epigenetic explorations: a transdisciplinary perspective on the evolution of modern knowledge societies ; part I, The Epigenetic Research Program (EPR) - basic building blocks ; part II, 'Great transformations' within modern societies - epigenetic transfer modules (TM)

Müller, Karl H.

Institut für Höhere Studien (IHS), Wien
Institute for Advanced Studies, Vienna

Reihe Soziologie / Sociological Series No. 32

The Great Societal Transformations: Epigenetic Explorations

A Transdisciplinary Perspective on the Evolution of Modern Knowledge Societies

Part I: The Epigenetic Research Program (ERP): Basic Building Blocks

Part II: The "Great Transformations" within Modern Societies: Epigenetic Transfer Modules {TM}

Karl H. Müller

The Great Societal Transformations: Epigenetic Explorations

A Transdisciplinary Perspective on the Evolution of Modern Knowledge Societies
Part I: The Epigenetic Research Program (ERP): Basic Building Blocks
Part II: The "Great Transformations" within Modern Societies: Epigenetic Transfer Modules {TM}

Karl H. Müller

Reihe Soziologie / Sociological Series No. 32

November 1998

Karl H. Müller
Institut für Höhere Studien
Stumpergasse 56, A-1060 Wien
Phone: +43/1/599 91-212
Fax: +43/1/599-91-191
e-mail: mueller@ihs.ac.at

Institut für Höhere Studien (IHS), Wien
Institute for Advanced Studies, Vienna

Die **Reihe Soziologie** wird von der Abteilung Soziologie des Instituts für Höhere Studien (IHS) in Wien herausgegeben. Ziel dieser Publikationsreihe ist, abteilungsinterne Arbeitspapiere einer breiteren fachinternen Öffentlichkeit und Diskussion zugänglich zu machen. Die inhaltliche Verantwortung für die veröffentlichten Beiträge liegt bei den AutorInnen. Gastbeiträge werden als solche gekennzeichnet.

Abstract

The subsequent two parts give a precise overview of a new and transdisciplinary perspective for the study of "knowledge based processes" in a wide variety of domains, including natural science fields and social science areas. The new approach which runs under the label of an "epigenetic research program" (ERP) is able, so the core message, to capture the evolutionary development patterns of the socio-economic and the socio-cultural world. This achievement is brought about through the construction of a conceptual, theoretical and modeling apparatus of sufficient transdisciplinary generality and through the separation of two different levels, namely of ERP-meta-levels on the one hand and ERP-levels of application on the other hand. Meta-level elements are characterized, above all, by their transdisciplinary status, being not linked to any particular type of application domain, whereas building blocks at application levels are clearly connected with special features in natural science or social science domains.

With respect to the set of two consecutive articles, Part I presents a general summary of the ERP-perspective and Part II is devoted to a set of ERP "transfer modules" mainly for the evolution of modern societies and their knowledge bases.

Zusammenfassung

Die zwei Artikel in diesem Heft geben eine konzise Übersicht zu einer neuen, transdisziplinären Perspektive für die Analyse "wissensbasierter Prozesse" innerhalb der unterschiedlichsten Bereiche in den Natur- und Sozialwissenschaften. Dieser neue Approach, der unter dem Namen "epigenetisches Forschungsprogram" (ERP) läuft, ermöglicht es, so die zentrale Botschaft dieses Reihenheftes, evolutionäre Entwicklungsmuster der "sozialen Welt" – in ihren sozio-ökonomischen oder sozio-kulturellen Seiten – einzufangen und zu identifizieren. Dieses neuartige Leistungspotential erschließt sich durch den Aufbau eines konzeptionellen, theoretischen wie modellmäßigen Apparats von transdisziplinärem Geltungsbereich und durch die Differenzierung in zwei Ebenen, nämlich in einen theoretischen, modellbezogenen wie einen generellen anwendungsorientierten transdisziplinären Bereich und in Transfermodule sowie Datenfelder, welche einzelnen Disziplinfeldern zugeordnet werden können.

Und hinsichtlich der Aufteilung der zwei Artikel offeriert der erste Teil eine Übersicht zu den einzelnen ERP-Bausteinen und der zweite Teil ein Set an "Transfermodulen" speziell für die Analyse der Entwicklung moderner Gesellschaften und ihrer so vielfätig gewordenen und weit verteilten Wissensbasen.

Keywords

Evolution, Complexity, Innovation, long-term pattern formations of modern societies

Schlagworte

Evolution, komplexe Modelle, Innovation, langfristige Musterbildungen moderner Gesellschaften

Contents

Introduction: Towards Evolutionary Social Sciences

Theories of evolution have become widely distributed over a very large number of disciplines mostly in the natural sciences, covering, moreover, some of the "hottest topics" within the current science domains like "morphogenesis", "cognition and adaptive learning", "artificial life" or "genetic engineering". A hostile take-over attempt from the genetic part of the evolutionary field to the social domains in the format of "sociobiology" has been highly unsuccessful both with respect to the explanation of social behavior and with respect to the reception within the social sciences, especially from anthropology or sociology. But in recent years, evolutionary considerations and frameworks have crossed the traditional confines which, so far, separated the social from the biological universe. In this manner, evolutionary economics has become by now a major strand within the social sciences, broadly conceived. Likewise, evolutionary management and organization theory has achieved a remarkable progress. Similarly, urban and regional science has become well-equipped with evolutionary modeling. In this spirit, the present paper attempts to pursue two different goals.

First, a very brief summary will be presented on a new research program, which runs under the heading of ERP – the epigenetic research program. This framework introduces a new basic vocabulary and attempts to function as a meta-theoretical framework applicable to a wide range of scientific domains in the natural and in the social sciences. One of the five core ingredients of the ERP-framework consists in classes of so-called transfer modules which bridge the gap between the meta-theoretical program and its disciplinary applications.

Second, a comparatively large number of transfer modules for a new type of an evolutionary macro-social science will be built up, demonstrating the cognitive fruitfulness of the ERP-perspective for the study of societal evolution. Here, a set of new tools on spatio-temporal boundaries as well as on development patterns will exhibit a series of co-evolutionary movements and trajectories at the global, national or regional level. Moreover, these new development visions are clearly of a Neo-Polanyian character, justifying, thus, the general heading of "Great Societal Transformations".

Third, the new architecture for modern knowledge societies will reveal, additionally, a new relationship between the co-evolution of societies and their knowledge bases, integrating, thus, traditional strands in the "sociology of knowledge" fields with macro-sociology.

In this manner, both the scope and the fruitfulness of the epigenetic program will become more transparent. Moreover, due to the precise character of the overall ERP-presentation as well as to the well-defined status of macro-societal ERP transfer modules, it might well be that a new hot topic is added to the already long list of widely debated evolutionary problems.

PART I: THE EPIGENETIC RESEARCH PROGRAM (ERP): BASIC BUILDING BLOCKS

Referring to a large amount of contemporary theorizing in the philosophy of science field (Donovan, Laudan and Laudan 1988, Stegmüller 1981, Sneed 1991, Balzer, Moulines and Sneed 1987), it seems reasonable to demand that any transdisciplinary research program for structures and processes for a multiplicity of space-time domains needs to specify five at least partially independent ensembles:

$$TRP = <\{TC\}, \{SpM\}, \{IA\}, \{TM\}, \{M\}>$$

More concretely, any transdisciplinary research program (TRP), and, *a fortiori*, the epigenetic research program, must accomplish five major building blocks in order to arrive at complete explanatory frameworks across a multiplicity of disciplinary fields.

> *First*, a theoretical core (TC) must be at hand in which the basic concepts as well as the fundamental relations and structures between these concepts are laid out.
>
> *Second,* a specific model or a class of formal models {SpM} must be specified which are applicable to the various disciplinary domains under consideration.
>
> *Third*, the realm of "intended applications" {IA} has to be delineated, providing general instructions of transdisciplinary nature both on the spatio-temporal as well as on the domain specific restrictions and limitations with respect to the applicability of the core-heuristics and of the group of special models.
>
> *Fourth*, special modules, labeled as "transfer modules;" {TM}, must be laid out which comprise all heuristic devices and assumptions necessary for the application of the conceptual core as well as of {SpM} to specific disciplinary fields.
>
> *Fifth*, a set of measurements {M} is needed, comprising quantitative or qualitative data as well as observation statements which summarize the empirical patterns, available for the domains to be explained.

Thus, it will become the main task of the subsequent chapter to present some clues on the structure and dimensions of these five epigenetic modules, starting with seven core-heuristics {TC}. (For closer details, see again Müller 1996a, 1998a)

1. A Generalized Theory of Evolution: The Theoretical Core-Heuristics {TC} of the Epigenetic Research Program (ERP)

The first chapter of Part I will be exclusively devoted to the presentation of seven core-heuristics which, taken together, stand at the center of the epigenetic approach. These core assumptions have been laid out in much greater detail in Müller 1996a, 1998a and will be summarized in a very brief, albeit concise manner.

1.1 A Generalized Notion of Evolutionary Systems

For any type of empirical analysis, the notion of "evolutionary systems" becomes, quite naturally, of paramount importance. Since not all developmental or growth processes should be qualified as evolutionary ones, a criterion of demarcation becomes necessary differentiating between evolutionary ensembles from other types of systems. One of the least controversial, though almost tautological criteria for evolutionary systems stresses a profound dualism in their modes of production and reproduction between their "genotype" and their "phenotype"-levels. In evolutionary biology, this distinction has a well-defined meaning, since, following Feldman 1988: 43 and many others, the observable properties, structures and processes of an organism belong to its phenotype and the sequence of nucleotides forming the DNA of an organism are qualified as its "genotype".

Within the epigenetic approach, a more generalized differentiation between these two domains will be proposed, differentiating, on the one hand, an array of "extended phenotype-levels" or, as they will be subsequently referred to, as "actor-network-levels" which are introduced as any observable, space-time unit with "operations" as well as with exchange and transfer relations with its environment and, on the other hand, "extended genotype-levels", or, alternatively, "embedded code-levels" which are to be qualified as any instruction or recipe-system with an indispensable role in the production or reproduction of an actor-network ensemble.

Following the above quite general differentiation, an epigenetic analysis *must* be performed at two different main levels *simultaneously*, one being associated with embedded code processes and their variations and the other with actor-network developments. Stated as a heuristic device, any investigation within the epigenetic framework has to specify its basic ensembles in terms of embedded code-systems and of actor-networks. While the exact nature of the relations between these two basic domains remains a center of heated controversies in developmental biology (See e. g. Dawkins 1995, 1997, Dennett, 1996, Goodwin 1995, Rosen 1996), the simple separation requirement is sufficient for the subsequent distinctions of these two basic areas for evolutionary systems.

1.2 The Epigenetic Square

Arranging the well-known evolutionary "chains of becoming" in a slightly similar fashion to Beninger (1986: 63), one arrives at Table 1.1, where basically four stages of the *extremely* long evolutionary run have been identified, where each stage develops a characteristic interaction pattern between code-system levels and the actor-network levels.

While the exact nature of these interrelationships will be discussed much more specifically in Part II of this paper, Table 1.1 gives rise to a dimensional scheme (Table 1.2), where the relations between embedded code and actor network levels occupy the centre stage. This new scheme runs under the heading of the "epigenetic square" and can be considered as the *basic* element within the seven core heuristics. Moreover, the five epigenetic dimensions, building up the epigenetic square can be used for an evolutionary analysis in a wide variety of domains — be they biological, anthropological, economic or social in nature.

As one can see from the epigenetic square in Table 1.2, the five dimensions exhibit an interesting connection to the stages in Table 1.1, since the program as well as the decoding dimension have been laid out during the early stages of life already, whereas the implicit dimension is of comparatively younger origin (100 million years ago).

Finally, the encoding dimension must be considered to be a human achievement only, coming into existence with the gradual emergence of pictorial codes and written code systems. (See also Deacon 1997)

The basic heuristic device, associated with Table 1.2, can be written in a very general manner, demanding that *any* type of research within the epigenetic tradition must be conducted by utilizing the five dimensions of the "epigenetic square".

1.3 "Embedded Code-Systems" and "Actor Networks" as Generalized Basic Concepts

Following the core heuristic, specified above, an additional conceptual instrument can and must be utilized, namely two core concepts for each of the two main evolutionary levels. For the code levels, a unified concept of "embedded code systems" has been proposed, whose main definitional requirements can be summarized in the following manner. An embedded code system has to exhibit —

Table 1.1: The Long-Term Evolutionary Chains

YEARS AGO (logarithmic)	
	STAGE I: Code ⇔ Code Interaction (Genetic Code) C ⇒ N Generation (Genetic Code) C ⇔ C Recombinations (Genetic Code)
1 billion	
	"Cambrian Explosion"
	STAGE II: Actor Network ⇔
100 million	Actor Network Interactions Learning by Imitations ("Implicit Knowledge") Tool-Utilizations, Communications N ⇔ N Recombinations
10 million	
1 million	
	STAGE III: Actor Network ⇒
100.000	Code Productions Learning by Encoding (Constructions of Human Codes especially Natural Languages and Number Codes)
10.000	
	Non-Pictorial Scriptures N ⇒ C Recombinations
1000	
100 years	
	STAGE IV:
10 years	Actor Network ⇒ Embedded Code Systems Productions: Genetic Code (GC) ∠ Bio-Technology Language) [1] Evolutionary Information Processing Systems, Based on Actor Network-
100 years +	Interfaces and Machine Codes

[1] ∠ stands for a "transcription relation", implying that a specific code-system has been transcribed or, alternatively, translated into another code-system. "Transcription relations" occur quite frequently like in the case of "morse code ∠ language code", etc.

Table 1.2: Five Basic Epigenetic Dimensions

Action-Patterns and Their Interactions and Adaptations

ACTOR NETWORK-DIMENSION

ACTOR NETWORK-LEVELS	N	⇔	N
	Decoding of	Co-Activation of	Encoding of
	⇑	⇕	⇓
	Programs	Action Patterns and Neural Programs	Programs
	DECODING DIMENSION	IMPLICIT DIMENSION	ENCODING DIMENSION
EMBEDDED CODE-LEVELS	C	⇔	C

Programs and Their Interactions and Adaptations:

Genetic, Neural, Human Code Systems, Machine Codes

DIMENSION OF PROGRAM POOLS

INDIFFERENCE OF CODE ELEMENTS — exchangeability of specific "marks" of a basic component in a code system

FINITE DIFFERENTIATION — a decidability in principle whether a given mark belongs to a specific code-character

COMBINATION OF CODE-ELEMENTS — the formation of composite sequences of code-elements

COMPARATIVE ADVANTAGES — evaluations of code-sequences in terms of a "fitness measure"

DYNAMIC EMBEDDEDNESS — the embeddedness of a changing code-system in a wider environment.

Likewise, the network levels have to use a single unifying concept across various domains, namely, not particularly surprising, the notion of "actor-networks" which have to fulfil the following five conditions —

VARIABILITY OF COMPONENTS — the composition of networks with highly heterogeneous classes and numbers of actors

INTERNAL EXCHANGES BETWEEN NETWORK-COMPONENTS AND EXTERNAL TRANSFERS WITH THE ENVIRONMENT — observable and measurable exchange and transfer relations between network nodes as well as between a network and its environment

COMBINATION OF ACTOR-NETWORKS — the formation of larger actor-networks, consisting of smaller ones

COMPARATIVE ADVANTAGES — explanation of network movements in terms of "attractivity/utility/fitness measures"

SIMULTANEOUS CHANGES — the dependence of the change in a network node from changes in other network components.

Two remarks must be added immediately in order to clarify the differences and similarities between these two concepts.

Table 1.3: A World of Embedded Code-Systems

DOMAIN	CODE-SYSTEM	CODE-ELEMENTS	EXTENDED CODE-ORGANIZATION
		EPIGENETIC REGIME I	
BIOLOGICAL AND HUMAN	Genetic Code	Four Bases: Adenin, Cytosin, Guanin, Thymin	Double Helix-Configuration
		EPIGENETIC REGIME II	
BIOLOGICAL AND HUMAN	Neural Codes	"Mental Agents" or "Neural Groups"	Cognitive Architectures within Actors
		EPIGENETIC REGIME III	
HUMAN "LIFEWORLDS"	Natural Languages	Letters of an Alphabet	Grammars
HUMAN "LIFEWORLDS"	Number Codes	Sets of Various Numbers $\{N\}$, $\{\Re\}$, etc.	Algorithms
HUMAN "LIFEWORLDS"	Pictorial Codes	Symbols from a Symbol-Library	Picture Programs[2]
HUMAN "LIFEWORLDS"	Musical Codes	Musical Notes	Musical Schemes
HUMAN "LIFEWORLDS"	Rule-Codes	Rule-Components	Encoded Rule Systems
		EPIGENETIC REGIME IV	
HUMAN "LIFEWORLDS"	Scientific Language in Bio-Technology (Biotech-Code)	Letters of an Alphabet, Numbers, Strings	Grammars, Transcriptions,
HUMAN "LIFEWORLDS"	Machine Codes	Strings, Alphabets	Grammars, Translations

[2] So far, very few explicit picture schemes are available at the moment, one of the most prominent being ISOTYPE (International System of Typographic Education) by Otto Neurath, Gerd Arntz et al. in the 1930's. (MÜLLER 1991b,c) It should be added though that the early code-systems within human history had been devised as pictorial or symbolic codes (WHITE 1995, CALVIN 1996).

First, the differences between both core concepts are comparatively weak since, following Mario Bunge (1977, 1978, 1983a, b), embedded code systems as well as actor networks both qualify as "systems" in the established sense of the word. Due to their *systemic* character, both levels of investigation can be combined in a rather convenient and straightforward fashion.

Second, the differences between these two different types of levels should be qualified more as epistemological ones than as ontological in character. In the end, the separations between ensembles at the code levels and formations at the network levels turn out to be, basically, a functional one, differentiating "recipe-collections" of various forms — genetic, neural, humanly encoded, machine-based — as units at the extended code levels and processes within the various (re)production domains as actor-networks at the network levels.

It must be added, at this point, that the two basic concepts — embedded code systems (ECS) for the code levels and actor networks (AN) for the network levels — are sufficient to analyze *any* context, in which "knowledge" or "information" (including "scientific production") may play a significant role. In other words, current utilizations of the term "knowledge" like knowledge as domains of discourse, as theoretical content, as "justified true belief", as results of learning processes or as scientific state of the art can be articulated and rephrased in terms of ECS- and AN-interactions. (For a detailed discussion, see Müller 1996a: 142 pp.) Whatever determines the shape and the dimensions of "knowledge-based processes", they can be formulated within the epigenetic framework, too.

1.4 A Generalized Framework for the Emergence of "Variations"

Sticking to the format of a meta-theoretical core framework, one must be prepared to find a *universal* mode of recombinations *across* different embedded code systems and *across* actor-networks:

The central point lies in a definition of "recombinations" — the generalized successor of the classic idea of "mutation" — across the multiplicity of levels. Here, the following set of requirements must be fulfilled for changes in any type of evolutionary system:

Full-scale *change* potential for an *embedded* code-system or actor-networks consists in having a rich repertoire of *recombination operators*, following them recursively, applying them at the meta-level, and modifying them accordingly. [3]

[3] The sentence above is a variation on a definition which Douglas R. Hofstadter has proposed for "creativity" — "Full-scale creativity consists in having a keen sense for what is interesting, following it recursively, applying it at the meta-level, and modifying it accordingly". (HOFSTADTER 1995: 313)

For the general case one can identify six conditions which must be present simultaneously.

> The *first* set of basic requirements is marked by the "rich repertoire-condition" which states that *successful* recombinations are dependent on a "requisite variety" (Ross Ashby) of the embedded code system or the actor networks. In other words, an embedded code-system with only random mutations as sole source of recombinations must be considered as a *very* poorly equipped recombination repertoire, whereas a "pandemonium of recombinative demons" across different levels fulfills the first requirement in an optimal way.
>
> The "rich repertoire-requirement" needs, *second*, the availability of *code-spaces,* which should have, in the general case, a single distinctive feature, namely a comparatively *large* area of unrealized code-sequences and, thus, a *high* potential for new sequences.
>
> The central area for recombinations resides, however, in the *third* requirement, namely in the availability of *recombination* operators which are able to generate in a recursive manner, starting from an initial scheme, new code-strings or programs at the extended code levels — or new action patterns at the extended network levels. For the general case, one is able to distinguish at least ten recursive operators which, following mostly Douglas R. Hofstadter (1995: 77), can be recombined by using some "adding operations" and which, then, can be subsumed under the headings of Table 1.4.[4]
>
> The requirements *four* and *five* demand a sufficient degree of flexibility — a capacity to *salient* adaptations (requirement four) — as well as of efficiency in approaching the target domains within a relatively *small* amount of time (requirement five).
>
> Finally, a *control*-capacity as well as a sufficiently powerful *support* system must be present which are not only able to secure the partial gains reached so far, but which, furthermore, develop at least *some* "gate-keeping"-functions and safe-guards against detrimental trajectories (requirement six) ...

It will become one of the main targets within the present recombination-chapter to demonstrate the *very* close "family resemblances" (Ludwig Wittgenstein) between recombinations at different levels of code-systems, including, especially, the phenomenon of scientific creativity as a particular case in question.

[4] In the following enumeration, terms like "building blocks", "scheme" or "code-elements" will be used simultaneously. In order to avoid a possible misunderstanding, it should be added that these three expressions refer to different degrees of complexity in embedded code-systems, from simple code-elements like letters to code-strings up to the level of programs or programs of programs ...

Table 1.4: A General Summary of Recombination Operators in Embedded Code Systems — and beyond

Adding:	the integration of new building blocks into an existing scheme
Breaking:	the differentiation of at least one scheme into two disjunctive building blocks
Crossing-over:	the breaking of at least two schemes and their merging into a new ensemble
Deletion:	the destruction of a specific building block from a set of schemes
Duplication:	the repeated insertion of at least one identical scheme
Inverting:	the making of copies with an opposite sequence of elements
Merging:	the integration of at least two existing schemes into a new one
Moving:	the shifting of code-elements or of established boundaries
Replacing:	the substitution of a code-element by another one
Swapping:	the movement from a level L_i to a different level L_j

The important point which *cannot* be over-emphasized lies in the *universality* of these recombination operations *across* various embedded code-systems — and *across* the many levels of actor networks.

1.5 A Generalized Framework for Processes of Diffusion

Like in the case of recombinations alias "mutations" or "variations", a richer conceptual apparatus is built up for the "selection" side of the epigenetic approach which has been generalized into a unifying "diffusion framework". The essential point to be added lies, very generally, in a family of evaluation measures f_i which, for reasons of convenience, may all be assumed to lie within the interval [0,1]. The evaluation measures must fulfill the following requirements:

First, they have to be applicable to both main epigenetic levels and, above all, to the recombinations within actor-networks and within embedded code systems.

Second, the evaluation measures should not be an all or nothing 0-1 attribution only but allow for small incremental changes between the [0,1] interval.

Third, the evaluation measures must exhibit a non-trivial linkage to the reproduction of units under consideration and, thus, to the population dynamics in question.

It becomes easy to see that the paradigmatic examples from a selectionist or genetic perspective, relying on "fitness" as evaluation measure, are contained as a special and relatively restricted case. Especially within economics and the social sciences, evaluation measures based on utilities, attractivities (Müller and Haag 1994) or on comparative advantages are widely used and fulfill upon closer inspection the three basic requirements stated above.[5] Moreover, the overall *potential* for "diffusion mechanisms", based on the essential role of the evaluation measures, can be summarized *via* a small generalized diffusion story.

> The starting point lies in the diffusion of a new ensemble — either at the level of actor-networks or of embedded code-systems — which has come into existence at some point within a spatio-temporal domain$_{C,N}$. Due to its *comparative advantages* (attractivity, fitness, strength, utility ...), the new ensemble is reproduced more rapidly and is recombined and improved in a variety of additional ways. *Via* these rapid replications, secondary, tertiary or quartary processes of adaptation are induced, which change the ecological domain$_{C,N}$ at times in a very significant fashion. Since the potential for further expansions of this new ensemble is more and more diminishing and will result relatively seldom in an all-eliminative outcome, further expansions will reach saturation limits. As a consequence, the comparative advantages change their basic direction from expansion to optimization and further changes lead to an optimization of the new ensemble and move it close to its "dominant design" ... Depending on the overall structuration of the spatio-temporal domain$_{C,N}$, the development pattern will exhibit a rich variety of shapes, ranging from logistic S-shaped diffusion to a quasi-cyclical pattern — clockworks with quasi-periodic successions of expansionary and optimization stages — or to an irregular succession — "bubbles" with no systematic succession of expansionary and optimization stages ...

At this point, it is interesting to note that the two most influential evolutionary accounts on economic development — the Schumpeterian vision — and on scientific revolutions — the Kuhnian framework — can be seen as domain specific instantiations of one and the same "basic structural story", following the quasi-periodical trajectories, just outlined above. More concretely, a few recombinative operations of substitution lead to the following developmental version, which is clearly very closely associated to Joseph A. Schumpeter:

---

[5] Take as a reference example from the *social* domain a school system with various types of schools as basic dual level components of an actor network, namely the national system of schools. In a series of applications, an attractivity measure has been developed which was built on synergy factors like agglomeration and saturations, on the relations to the employment sphere or on the likely effects towards the university system. Moreover, this attractivity measure for various school types was *directly* linked to the ecological dynamics of school types since higher attractivities exerted a push/pull effect on pupils, leading, thus, to higher than average growth rates and, consequently, to higher than average reproduction rates for more attractive school forms. For more details, see Haag and Müller, 1992, Müller and Haag, 1994.

Performing, once again, a very small number of substitution operations, one arrives at the subsequent diffusion story in which the majestic Kuhnian clockworks have come into full swing.

It goes almost without saying that both versions of diffusion clocks, the Schumpeterian and the Kuhnian clockwork, are subject to a rich variety of complex models, ranging from dynamic networks of the type of "master-equations" to neural networks, adaptive systems or to conceptualizations in terms of "self-organized criticality".

1.6 Multiplicity of Units for the Extended Code and the Extended Network Levels

In order to stick to the format of a small overview of the epigenetic core program, the sixth heuristic can be summarized in a *very* short manner: The units of evolution, according to the epigenetic program, are distributed over a rich multiplicity of different "building blocks" both across the extended code and across the extended network levels.

In other words, building blocks, capable of evolutionary development, can be constituted in a *practically* infinite number of ways, ranging, confined to the extended network levels alone, from individuals, households, groups, economic sectors, art groups, research units to cities, regions, nations and the like.

1.7 Self-Referentiality and "Second Order-Investigations"

Finally, the last core heuristic of the epigenetic program refers, once again very generally summarized, to the recombinability of the existing six core-heuristics into a self-referential manner so that probably a most fascinating class of scientific problems like —

Code-systems of code systems, diffusion of diffusion, emergence of emergence, evolution of evolution, function of functions, models of models, networks of networks, recombinations of recombinations, —

can be successfully analyzed with the conceptual tools and relations developed so far.[6]

---

[6] Again, restrictions in space prevent a fuller description of this specific point, which, however, has been laid out in greater detail in Müller 1998a.

Table 1.5: A General Overview of the Multiplicity of Building Blocks within the Extended Code and the Extended Network Levels

				Multiple Space-Time-Levels$_N$ Macro$_N$/Meso$_N$	
			Global S/M/L	National S/M/L	Regional S/M/L[7]
	Multiple Building Blocks				
		High	Field$_1$	Field$_2$	Field$_3$
	Macro$_N$	Medium	Field$_4$	Field$_5$	Field$_6$
		Low	Field$_7$	Field$_8$	Field$_9$
Extended Network Levels		High	Field$_1$	Field$_2$	Field$_3$
	Meso$_N$	Medium	Field$_4$	Field$_5$	Field$_6$
		Low	Field$_7$	Field$_8$	Field$_9$
				Multiple Space-Time-Levels$_N$ Micro$_N$	
			Wide F/P/M	Medium F/P/M	Small F/P/M[8]
	Multiple Building Blocks				
Extended		High	Field$_1$	Field$_2$	Field$_3$
Network		Medium	Field$_4$	Field$_5$	Field$_6$
Levels		Low	Field$_7$	Field$_8$	Field$_9$

				Multiple Space-Time-Levels$_G$ Macro$_C$/Meso$_C$	
			Global S/M/L	National S/M/L	Regional S/M/L
	Multiple Building Blocks				
		High	Field$_1$	Field$_2$	Field$_3$
	Macro$_C$	Medium	Field$_4$	Field$_5$	Field$_6$
		Low	Field$_7$	Field$_8$	Field$_9$
Extended Code-Levels		High	Field$_1$	Field$_2$	Field$_3$
	Meso$_C$	Medium	Field$_4$	Field$_5$	Field$_6$
		Low	Field$_7$	Field$_8$	Field$_9$
				Multiple Space-Time-Levels$_C$ Micro$_C$	
			Wide F/P/M	Medium F/P/M	Small F/P/M
	Multiple Building Blocks				
Extended		High	Field$_1$	Field$_2$	Field$_3$
Code-		Medium	Field$_4$	Field$_5$	Field$_6$
Levels		Low	Field$_7$	Field$_8$	Field$_9$

[7] S, M and L stand for short-, medium-, and long-term processes at the network and at the code levels. For closer details, see Müller 1998a.

[8] F, P and M are conceptualized in a weak analogy, refering to fento-, pico- or micron-processes. Again, closer details can be found in MÜLLER 1998a.

2. THE EPIGENETIC RESEARCH PROGRAM: ADDITIONAL BUILDING BLOCKS

2.1. Families of Complex Models as {SpM}

The first additional building block can be summarized in a very short manner, stating that the models, associated with the epigenetic program, are co-extensive with the emerging classes of complex models which have been laid out in Table 2.1. From here, one can easily see that these models share a set of unusual features like —

complex formal structures (e. g., non-linearity) or complex aggregation procedures

non-trivial arrangements with respect to the input-output-transformations

a high degree of applicability in heterogeneous domains, ranging from the natural sciences to the social sciences.

2.2 Generalized Intended Applications {IA}: A Short Summary

The realm of "intended applications" of a transdisciplinary research program specifies three basic types of *general* utilization devices irrespective of disciplinary domains which are necessary for the implementation of {TC} and {SpM}. The three main areas, associated with the intended ERP-applications, can be summarized under the following headings.

General arrangements for the ERP-program for its descriptive or explanatory applications

ERP-linkages to cognitive advances which may lead to an adaptation of the core-heuristics {TC} or of {SpM} within the epigenetic research program

the organizational profile of the epigenetic research program.

In addressing these three basic domains, seven generalized application heuristics can be presented which, taken together, constitute the {IA}-class of ERP.

Table 2.1: Families of Complex Models for the Epigenetic Approach

TRADEMARKS	CORE-DOMAINS AND FIELDS OF APPLICATION	CORE CONCEPTS, HEURISTICS
Adaptive Systems and Control Theory	Biology, Engineering, Economics, Sociology et al.	Anticipatory Systems, M-R Systems (Metabolism-Repair Systems) et al.
Artificial Life	*Artificial Intelligence*, Robotics, Biology et al.	*Subsumption* architectures; Cellular Automata; Viral Replications et al.
Autopoiesis	*Biology*, Artificial Intelligence, Theories of action, *et al.*	Organisation/ Structure; Closedness, Autonomy; Recursiveness; Observer-dependence et al.
Cellular Automata	*Engineering*, Physics, Biology, Demography, Sociology, Ethics et al.	von Neumann neighborhood, Moore neighborhood et al.
Chaos-theory	*Dimension-theory*, Meteorology, *et al.*	*Strange Attractors*; Mandelbrot-Set; Julia-Set; Ljapunov Coefficients et al.
Classifier Systems and Evolutionary Programming	*Engineering*; Artificial Intelligence, Biology, Management Science Economics *et al.*	Classifier Rules; *Bucket Brigade Algorithm*; *Cross-over* et al.
Complexity Theory	Computer Architecture, Artificial Intelligence, Linguistics, Biology, Sociology et al.	Deterministic Turing machines, NP-Problems et al.
Dissipative Structures	Nonequilibrium Thermodynamics, *Chemistry, et al.*	Disturbance-parameters; Brüsselator et al.

Table 2.1: Families of Complex Models for the Epigenetic Approach (continued)

TRADEMARKS	CORE-DOMAINS AND FIELDS OF APPLICATION	CORE CONCEPTS, HEURISTICS
Evolutionary Gametheory and Rational Choice	Biology, Neurophysiology, *Sociology*, *et al.*	Evolutionary Stable Strategies (ESS) et al.
Group Theory	*Mathematics*, Quantum Theory, Chemistry, Psychology, Sociology et al.	Groups, Symmetry Operations, Symmetry Groups et al.
Hypercycles	*Biochemistry,* Chemistry, *et al.*	Families of Nonlinear Equation Systems et al.
Neural Networks	*Computer Science*; Neuro-Sciences, Artificial Intelligence, Cognitive Science, *et al.*	*Delta rule*; *Back propagation algorithms* et al.
Population Dynamics	*Biology*, Ethology, Demography, Economics, Sociology et al.	Models of Selection, Predator-Prey-Models et al.
Self-Organized Criticality	*Physics*, Geology, Meteorology, Economics et al.	Recursive Power-Functions; Critical Thresholds, etc.
Synergetics	Laserresearch, *Physics*, Pattern Recognition, Chemistry, Sociology, *et al.*	Masterequation; Fokker-Planck-Equation; Slaving Principle; Control- and Orderparameters, et al.
Theory of Catastrophes	*Differentialtopolgy*, Biology, Sociology, *et al.*	Families of Generic Equations; Typology of Bifurcations et al.

First, the descriptive and the explanatory ERP-arrangements can be summarized, on the one hand, *via* Table 2.2 and, on the other hand, *via* three basic explanatory requirements which, moreover, could be qualified as *necessary* conditions for the construction of evolutionary explanations in science.

With respect to the *descriptive* apparatus, the following summary may serve as a useful reference point since it combines and integrates the seven theoretical core-heuristics (epigenetic architecture (1,2), building blocks (3), recombinations (4), evaluation measures (5), multiplicity of units (6) and, although not explicitly recognizable, the second order applicability (7). Alternatively, epigenetic descriptions must be constructed in a way as to fulfill the specification requirements presented in Table 2.2. {IA_1}

Table 2.2: Descriptive Application Requirements of the ERP-Program {IA_1}

	UNITS	CHANGES
SYSTEMIC COMPONENTS:	Types of Building Blocks; Types of Reproduction; Dual Level-Architecture	Average Reproduction Requirements; Types of Recombinations; Comparative Advantages/ Disadvantages
ENVIRONMENTAL COMPONENTS:	Types of Building Blocks; Types of Reproduction; Dual Level Ar-Chitectue	Average Reproduction Requirements; Types of Recombinations; Comparative Advantages/ Disadvantages
SYSTEM-ENVIRONMENT RELATIONS:	Types of Internal and External Relations within the Dual Level Architecture; Types of Internal and External Disturbances	Changes of Internal and External Relations within the Dual Level Architecture; Changes of Internal and External Disturbances

For *evolutionary* ERP-*explanations*, three basic necessary conditions can be specified which must be met simultaneously, namely –

(1) the availability of a complex explanatory framework, selected from the class of complex models {SpM}

(2) the integration of an "evaluation measure" which occupies a non-trivial role within the *explanans*-part

(3) the integration of explanatory-components from *both* main epigenetic levels, *i. e.* from the actor network levels *and* from the code levels.

These three basic conditions, combined, constitute the second generalized application heuristics for the ERP-approach. {IA_2}

To provide a concrete example, an explanation of the movement of pupils within the Austrian education system can be qualified as *evolutionary* (for more details see Haag and Müller 1992, Müller and Haag 1994 and Müller and Haag 1998) since

(1) the explanatory framework comes from the fields of "master equations" in Table 2.1 (non-linear dynamic networks within the "synergetics family")

(2) an "evaluation measure" – attractivities for various school types – has been provided in a clearly *non*-trivial manner

(3) explanatory elements stem both from the code-levels (school regulations with respect to legal and illegal transitions between school types) *and* from the actor network levels (e. g., relations of a specific school type to the employment sphere)

For the relations between {TC} or {SpM} with advances in the scientific knowledge base, one may specify —

> Close ties with the evolution in *complex modeling* which implies a strong modification pressure in terms of the enumeration of complex modeling approaches presented under Table 2.1. {SpM} {IA_3}
>
> Close linkages to the current status of *material* frameworks, especially in the areas of evolutionary theory, including artificial life, of the cognitive sciences, of linguistics, of artificial intelligence since advances in these domains may lead to modifications with respect to the (re)production of basic units, to their basic conditions and to their comparative advantages. {IA_4}
>
> Close links with advances in *methodology*, especially in the fields of philosophy of science, especially, but not exclusively, of the structure of research programs, of new methodologies for transdisciplinary research, of "theory testing", etc. {IA_5}

With respect to the organization of scientific units within the ERP-framework, a very general remark can be provided, stressing the Mode II character (Gibbons et al. 1994, Nowotny 1995, 1996) of the entire approach. More concretely, The organizational profile of ERP should exhibit a high degree of inter- or transdisciplinary group composition, an interface between basic research and applied science, establishing, thus, a *unity* between the context of application and the context of discovery. {IA_6}

Finally, the "intended ERP-applications" can be assumed as unusually wide and general, culminating in a rich variety of ways, especially in "empirical" applications *and*, due to its firm rooting in the modeling realm, in "possible world-utilizations" or, alternatively, in simulations.[9] $\{IA_7\}$

Thus, the scope of ERP assumes a *very* generalized application profile which might offer, due to its heterogeneous domains, an interesting basis for a well-integrated "life science" of transdisciplinary nature.

2.3 Transfer Modules {TM} and Measurements {M}

Finally, two additional components must be available especially for specific applications and utilizations of a transdisciplinary research program. First, at a more general level of disciplinary applications, "transfer modules" {TM} can be considered as recombinations of building blocks of meta-level ERP-modules with empirically accessible conceptualizations and measurement operationalizations. Thus, "transfer modules" like the notion of "epigenetic regimes" integrate space-time specifications or specific patterns of relations between code- and network-levels with elements from the theoretical core {TC} and from classes of special models {SpM}. Thus, a direct link can be established between the meta-level domains and the realm of transfer modules. Likewise, transfer modules are of considerable importance in shaping the meta-side of ERP, leading thus to linkages from {TM} back to the meta-level ERP as well.

Second, the devices and schemes {M} for ordering the results of measurements cover the fifth and final module of the ERP-program. Here, a rich pool of discipline specific measurements, data and instruments must be available which, in combination with the first four modules, can be either used for ERP-descriptions or ERP-explanations.[10]

---

[9] On the modal distinction between actual world/possible world in social science modeling, see MÜLLER 1996c.

[10] For two concrete applications, utilizing the whole range of ERP-modules, see especially Müller and Turner, 1998, Part III. These complete applications will be of descriptive and explanatory nature, covering, on the one hand, inherent "knowledge loops" within a large Non-Profit organization in Austria and, on the other hand, the long-term development patterns in the Austrian education system.

PART II: THE "GREAT TRANSFORMATIONS" WITHIN MODERN SOCIETIES: EPIGENETIC TRANSFER MODULES {TM}

Part II will demonstrate that the ERP-framework offers a variety of new ways to capture, even in a typological manner, the basic evolutionary development patterns of modern human societies, past and present. Thus, the subsequent set of transfer modules exhibits a series of (partially) new instruments for "knowledge based" macro-societal analyses. These instruments, tables, tools and diagrams, in conjunction, stand at the core of transfer modules for a complex analysis of societal transformation processes. Consequently, Part II will be concerned mainly with the transfer modules themselves and not, at least not within this publication, with their empirical application in the context of macro-societal evolution. [1]

1. A TRANSFER MODULE FOR THE SPATIO-TEMPORAL DIMENSIONS OF MODERN KNOWLEDGE SOCIETIES

The transfer modules Ia and Ib (Tables 1 and 2) present essential hints on the "hidden co-evolution" between the two main epigenetic levels in modern societies, *i. e.*, between the actor network formations and the "knowledge bases". Moreover, these transfer modules on spatio-temporal domains within modernity may be seen as a recombination of the epigenetic approach with fundamental insights from Karl Polanyi on societal formations (1978, 1979), Immanuel Wallerstein (1979, 1984, 1991, 1995) on the emergence of the "modern world system" and, finally, Joseph A. Schumpeter (1961, 1975) on the "engines of economic creation and destruction".[2] Thus, the subsequent spatio-temporal orderings should provide a useful basis for contemporary discussions on periodizations.[3] From Table 1, one can derive four important assertions for the network levels.

> *First*, the *basic* difference between societal formations prior to 1450/1500 and the modern world-system emerging in a seemingly irreversible manner during the "long 16th century" must be seen in the rapid evolution of *global economic* actor-networks with *limited* regional controls at the level of political systems only. In other words, self-organization and self-regulation have established themselves as the principal ways of societal differentiation and development at the network levels, coordinating

---

[1] In a follow-up publication within this series, a complete complex modeling process, including data {M}, will be summarized, exhibiting the full explanatory scope of the epigenetic program. (See Müller and Turner 1998, Part III)

[2] Quite obviously, the rich repertoire from current theorizing on societal development has been considered as well in shaping the epigenetic transfer modules of Part II. But assessing the relative importance of various contributions, the classical "visions" by Polanyi, Schumpeter and Wallerstein should be viewed as of central relevance.

[3] On some of the fundamental problems in this area, see esp. Aveni, 1989.

not only the production and flows of goods and services, but also of labor, land, natural resources and the state of the environment.

Second, the world-historic turn towards *self*-organizing markets —

The economy is no longer embedded in social relations, but the social relations are embedded into the economic system (Polanyi, 1978:88f.)[4] —

does not start in the 18th or even 19th century but should be viewed, following the analyses of Immanuel Wallerstein or, alternatively, Fernand Braudel,[5] as an *emerging* process from the early decades of the 16th century onwards. With the death of Charles V. in 1531 at the latest, the modern world system had reached its *supra*-critical stage,[6] upon which no reverse trajectory back to redistributive formations lay in the *reachability* of the ongoing market-evolution. Consequently, the core actor networks of the world system in North-Western Europe entered a continuous process of becoming economically stronger integrated and interlinked.[7]

Third, a *global* process of economic network integration can be observed, differentiating the *external* regions of the world system either in a semi-peripheral or, most frequently, into a peripheral position and role. This global absorption process has seen some spectacular "big spurts" and *upward*-mobility from external to semiperipheral and, finally, to core status like the case of Japan or from peripheral to semi-peripheral level like the big jump of South Korea after 1945. Surprisingly, no *downward* mobility of significant dimension can be recorded within the evolving world system since the core regions of the 16th century still belong to the core or to important semiperipheral areas of the world system five centuries later.

Fourth, a final remark must be reserved to the future developmental potential of the worldwide market networks. According to Table 1, the half millennium or so of global evolution through self-organizing markets has entered the stage of transnational evolution and possesses a vast array of *upward* trajectories giving rise to new forms of global stabilization too. Looking back to two historical periods, one important feature of the evolving market network formations must be stressed.

---

[4] Translation by K:H. Müller from Polanyi 1978.

[5] Here, one must refer to the impressive work by Braudel, 1982, 1986.

[6] It would be an extremely challenging research task to introduce the *metaphorical* notions of supra- and sub-criticality to the *market network* developments in the Mediterranian region, centered around Venice, Genova, etc. around the 12th and 13th century and the subsequent pattern in North-Western Europe, especially between Northern France, the Netherlands and the Southern and Middle parts of England. The most interesting problem in this area has to do with the question whether essential systemic indicators can be identified which would indicate subcritical and supracritical masses for a successful and expansion-driven market network-development.

[7] For a similar "developmental vision", see also Perroux, 1983, Pollard, 1981 or Rostow, 1978.

> *First*, a closer inspection of the second half of the 19th century reveals the existence of global stabilisators like, following Karl Polanyi, the gold-standard, the liberal state as well as an international equilibrium of great powers (Polanyi, 1978: 59 pp.).
>
> *Second*, in the thirty years after 1945 the world-economic ensemble stood under the heavy influence of a *pax americana*, free trade and the Bretton Woods arrangements, which have come into existence *within* a self-propagating market system.
>
> Thus, it should be viewed as highly probable that in the future, too, new *global* mechanisms for coordination and "supervision" (Helmut Willke) will accompany the ongoing transnational evolution and the resulting high horizontal mobility of production processes around the globe. The "Great Transformation" will *continue* its great transformations ... (Polanyi, 1978: 295)

In a similar manner, a spatio-temporal map for the knowledge pools can be constructed which is then depicted in Table 2. Unfortunately, due to the novelty of the overall epigenetic framework, many linkages between knowledge-actor network relations are not particularly well understood or even analyzed in a rudimentary manner. Nevertheless, four important features of Table 2 can be mentioned.

> *First,* the most surprising feature of Table 2 lies in the fact that the essential spatio-temporal network differentiations *can* be applied to the code levels as well. Although some important differences prevail, the *deep* similarity in the evolutionary development patterns of knowledge pools and actor network formations remains unaffected. Thus, it is not only possible and heuristically fruitful, to differentiate between core, semiperipheral and peripheral *program* or *knowledge* pools, but it is also rewarding from a cognitive point of view, to introduce pre-capitalist forms of knowledge production of the "distributed" and "centralized" variety and to define periods and stages like an "age of global distribution", and, for the 20th century, an "age of transnational evolution".
>
> *Second*, the scientific production has always carried with it a strong tendency toward "globalization", although "globalization" is to be understood in terms of the evolving world-economy only (see also Merton, 1985). Thus, despite the seemingly global discourses between scientific centers throughout the 18th century in Paris, London, Edinburgh, Berlin, the American East Coast or St. Petersburg, many *external* territories and their knowledge traditions, especially in Africa, have not only been excluded, but also de-qualified and mis-understood in a very *profound* manner. (See, e. g., Raynal and Diderot, 1988, Hegel, 1956)

Third, following the last point, it becomes possible in a non-trivial manner to differentiate between *three* genuinely regional types of knowledge bases within the global knowledge pools. Utilizing the same spatial distinctions which have been employed for actor network formations, an analogous separation can be made for the code levels and, thus, for the knowledge bases, too.

Core Knowledge Bases: In the *first* instance, knowledge production within specific regions is highly distribution-oriented, setting the standards of the "state of the art" within specific fields of inquiry *elsewhere*, too. Judged from an "intellectual balance of international exchanges", the core knowledge base is *diffusion* driven, exhibiting a *global* diffusion potential but being highly selective, in turn, with respect to knowledge bases and programs from other regions. In terms of operationalizations and measurements for the present time, SCI-groups (science citation indicators) must exhibit a clearly asymmetrical pattern in which articles from core regions quote mainly other core region publications while, in turn, they are being quoted throughout the semiperipheral or peripheral knowledge bases.

Semiperipheral Knowledge Bases: For the *second* type, a genuine *mixture* between core features and peripheral features can be recorded, since semiperipheral knowledge bases show areas of high *global* competence with a correspondingly high diffusion potential as well as research fields with predominantly reception-centered features only.

Peripheral Knowledge Bases: The *third* type, finally, is mainly *reception* driven, exemplifying a high reception potential but being only marginally reproduced and recombined in other regions. Once again seen from an "international balance of international exchanges", the peripheral knowledge base is characterized by a *local* diffusion potential only, although it is able, albeit with a certain time lag, to *reproduce* the state of the art-standards set in core or semiperipheral knowledge bases. Again, peripheral knowledge production is highly asymmetrical in terms of SCI-values, exhibiting comparatively low impact values for other regions of the world.

In this manner, an empirical basis for main types of regional knowledge pools can be established.

Table 1: Main Evolutionary Actor-Network Stages in the Great Transformations of Modern Societies $\{TM_{Ia}\}$

SOCIETAL ACTOR-NETWORK FORMATIONS

Reciprocal Formations	**Redistributive Formations**	⇒	**Capitalist Formations**
Societies under Dominance of *Personal Exchanges*	Societies under Dominance of the *Political* System	⇒	Societies under Dominance of *Markets*

⇓⇓⇓⇓⇓⇓⇓

CAPITALIST TRANSFORMATIONS

THE GLOBAL DEVELOPMENTAL STORY	
	Initial Phase I: 1450 - 1600: *(ir)reversible Expansion*
	Initial Phase II: 1600 - 1760: *Consolidation*
Gradual integration of reciprocal as well as re-distributive societal formations; Global differentiation into three distinct regions: *core regions, semi-peripheries* and *peripheries*.	**Global Diffusion** (1760 - 1920)
	Industrial Revolution: 1760 - 1820
	Prosperity 1780/90 - 1820
Specific development patterns in each of the three global regions, reaching from differences in the world trade-relations to significantly different roles and capacities of national governments or to different compositions with respect to socio-economic status-groups or classes;	*Global Diffusion*: 1820 - 1913/20
	Depression 1820 - 1842/50
	Prosperity 1850 - 1870/73
	Depression 1873 - 1893/96
	Prosperity 1896 - 1913/20
Emergence of global instruments for coordinating and balancing the world-system, leading, in the *very* long run, to the development of global institutions and organizations; emergence of new types of "knowledge and information societies;	**Transnational Evolution** (1920 - 1973)
	Depression 1920 - 1938/48
	Prosperity 1948 - 1966/73
Dense intra-systemic and inter-systemic networks in production processes; integration of global and local accessibilities, etc.	Depression 1973 - 1993/97
	Prosperity 1997 - ???[8]

[8] For the special choice of periods, the selections have been undertaken with respect to the common upper and lower boundaries of "long swings". On this point, see especially Freeman 1983, 1986, Freeman and Soete, 1994 or Kleinknecht, 1987.

Table 2: Main Evolutionary Knowledge Base-Stages in the Great Transformations of Modern Societies {TM_{lb}}

SOCIETAL KNOWLEDGE BASE-FORMATIONS

Distributed Knowledge Bases	**Centralized Knowledge Bases**	⇒ ⇒ ⇒	**Capitalist Knowledge Bases**
Knowledge Bases under No Pro- *tection of Special Systems*	Knowledge Bases under the Dominance of a Knowledge Generating System	⇒ ⇒ ⇒ ⇒	Knowledge Bases under the Dominance of Modern Forms of Knowledge Generation

⇓⇓⇓⇓⇓⇓⇓

CAPITALIST TRANSFORMATIONS

Initial Phase : 1450 *(Ir)rev.* 1760:*Expansion* and *Consolidation*

THE GLOBAL DEVELOPMENTAL STORY

Gradual integration of distributed as well as centralized knowledge bases; Global differentiation into three distinct regions with respect to the (re)production and to the accessibilities of local or global knowledge bases: *Centers, Semi-peripheries* and *Peripheries.* Specific development patterns in each of the three global regions in the area of program-pools, ranging from differences in regional roles- and capacities for "knowledge pro- duction" at the level of firms and markets; Differential access to the knowledge bases in cognitive core-areas; Development of limited local knowledge traditions and "subversive knowledge" against the established forms of programs within cognitive core-areas; Emergence of new types of knowledge societies; Decisive steps toward globalized program pools due to the formation of the internet, integrating the global *and* the local program production, etc.

Global Distribution
(1760 - 1920)

"Institutional and Organisational Revolution": 1760 - 1820
Emergence of New Types of Universities (Combination of Research and Education)
Global Diffusion: 1820 - 1913/20

Gradual Recombination of R&D and Firms through Firm-Specific Research Laboratories

Transnational Evolution
(1920 - 1973)

Phase Transition from "Little Science" to "Big Science" Compounds

(1973 - ???)

New Stages, due to the Emergence of Bio-Technology and a Global "Knowledge System" based on "Machine Codes"

Fourth, program production for regional, national or for the global knowledge pools became, seen in a *very* long perspective, closed and confined to specialized societal segments regionally, nationally and globally, namely to a dense network of scientific and technical institutions at the clear exclusion and expense of local knowledge traditions, of local "knowledge producers" and of the public sphere in general. Here, a successful "closure movement" has set in which fulfills by and large successful "gate-keeping operations" against private scholars or *non*-scientific practitioners in science, technology or medicine.

With these qualifications, a scheme for ordering spatio-temporal units in the evolution of the "modern world system" both for the code and the network levels have been laid out as epigenetic transfer module No.1.

2. TRANSFER MODULES FOR THREE CO-EVOLUTIONARY ENSEMBLES ACROSS AND BETWEEN CODE AND NETWORK LEVELS

Having, thus, specified the spatio-temporal orderings within the long-term space-time domains of actor network ensembles and knowledge base formations, a new transfer module must be built up for the main patterns of development within these spatio-temporal schemes. Aside from a specific cyclical pattern, linked to the "long swings" of basic product innovations in the world system (Dosi et al., 1988, Marchetti, 1981, Schumpeter, 1961), the Polanyi notion of "double movements" or, alternatively, of co-evolution will be put to the center of analysis. As will be shown within the next four steps, co-evolutionary or "double movements" can be identified between a special class of actor network formations (2.1), within the knowledge bases (2.2) and between network and code-levels (2.3). Finally, one will be led to a comparatively new typology for "embeddedness relations" which, following the epigenetic square, can be grouped into horizontal and vertical forms of embeddedness (2.4).

Moreover, one may postulate that the subsequent conceptual scheme of "embeddedness relations" can be safely applied to a multiplicity of spatial levels, starting from a global perspective down to a national or a regional one, to the level of towns and communities. Also for small or medium-sized organisations, for households, for groups, individuals or even for sub-individual building blocks (Ainslie, 1992), the notion of "embeddedness relations" can be utilized in an intriguing and very far-reaching manner.

2.1. THE CO-EVOLUTION OF MARKET NETWORKS AND NETWORKS IN THE "PROTECTIVE BELTS"

With respect to actor network ensembles, it is comparatively easy, following, above all Karl Polanyi, to distinguish two main classes of networks, namely, on the one hand, market networks and, on the other hand, a societal network for safeguarding and restricting markets which will be labeled as "societal protective belt".

From an epigenetic point of view, the central characteristic of market networks can be formulated in the following way. Markets are to be considered as a distributed network of dual level organizations (mainly firms of varying sizes, including self-employed individuals), exhibiting a core reproduction requirement (average profits) and comparative advantages via product-, process- or organizational innovations as well as a self-organizing mode of expansion.[9] More precisely, one can list the following characteristics of self-organizing market networks.

> *First*, one has to conceptualize markets as a system of interacting autonomous units. The *differentia specifica* of modern markets consists in the emergence of supra-critical market-networks for special products and services as well as in the interlinkages of special markets to a globally interlinked self-perpetuating network, being composed of a supra-critically large number of autonomous components.[10]
>
> The overall direction of the economy is determined by the interaction of many dispersed units acting in parallel. The action of any given unit depends upon the state and actions of a limited number of other units (Holland 1988: 117).
>
> *Second*, the global market network expands and, at times, contracts beyond any global control-systems of political origin or any other type for that matter.[11]
>
> There are rarely any global controls on interactions — controls are provided by mechanisms of competition and coordination between units ... (Holland, 1988: 118).
>
> *Third*, modern markets exhibit, as a global network of many local networks, a high variety and stratification, both at the horizontal and at the vertical dimension.[12]

---

[9] Although the stock of complex or self-organizing network models will be dealt with more intensively in a subsequent publication (Müller and Turner, 1998), some examples should be quoted at this point, too, like Anderson, Arrow and Pines, 1988, Arthur, 1989, Batten, Casti and Johansson, 1987, Haag, 1989, Metcalfe 1997, Nelson and Winter, 1982 or Zhang, 1991.

[10] Since the connections between Schumpeter and evolutionary economics have become a truism by now, another parallel may be more enlightening and surprising, namely the linkages between evolutionary economics on the one hand — and Karl Polanyi. In Polanyi's works, one finds a highly interesting charcterization of an "evolving market economy" which, in quintessential aspects, turns out to be quite similar to the description provided for example by John H. Holland. For a similar vision in Polanyi, see e. g. Polanyi, 1978: 71.

[11] Once again, one may find a similar conceptualization of economic development in Karl Polanyi (1978: 71)

[12] Polanyi characterizes markets in a similar way as a huge network of interlinked markets (Polanyi, 1978: 07.

The economy has many levels of organization and interaction. Units at any given level typically serve as 'building blocks' for constructing units at the next higher level. The overall organization is more than hierarchical, with all sorts of tangling interactions ... across levels (Holland, 1988: 118).

Fourth, from their basic components, namely small, medium and large-scale enterprises in any of the three main economic sectors (agriculture, industry and services), market networks can be characterized by a high degree of *recombinability* and *adaptability*.[13]

The building blocks are recombined and revised continually as the system accumulates experience — the system adapts (Holland, 1988: 118).

Fifth, the evolution of a market network of market-network facilitates processes of differentiation and specialization or, alternatively, implies the disappearance of "universal" market-components, being able to fit into *any* niche.[14]

The arena in which the economy operates is typified by many niches that can be exploited by particular adaptations; there is no universal super-competitor that can fill all niches .... (Holland, 1988: 118.

Sixth, in the course of market expansion and growth, a continuous opening up or closing down of niches occurs so that, from its inner logic of expansion, no limits to growth can be identified. Moreover, the most important element for the reconfiguration of the basic building blocks for market networks, namely enterprises, lies in the change of *socio-technical systems* employed within these enterprises. Thus, the flow of recombinations must be conceptualized as an unrestricted process, being hampered only by concerns of risk, profitability, social acceptance, environmental consequences and the like.[15]

Niches are continually created by new technologies and the very act of filling a niche provides new niches ... Perpetual novelty results (Holland, 1988: 118).

Seventh, due to the continuous opening up and closing down of niches, no global optimum can be specified for the market networks both at the global as well as on the local levels. On the contrary, a permanent process of recombinations and

[13] Once again, one may find an interesting parallel in the writings of Karl Polanyi (1978: 183).
[14] Another work of evolutionary "family resemblances" between John H. Holland and Karl Polanyi can be found at Polanyi (1978: 130 pp.).
[15] Even for this case, one can detect very similar notes in Karl Polanyi (1978: 110p.).

adaptations creates, *during* its own operations, a multiplicity of *local* "basins of attractions".[16]

Because the niches are various, and new niches are continually created, the economy operates far from an optimum (or global attractor). (Holland, 1988: 118)

According to the self-organization perspective for market networks just outlined, the main processes to be analyzed lie in the *great transformations* of a comparatively small global market-network at the beginning of the 16th century to an all-encompassing, highly integrated market-network of market-networks at the end of the 20th century. Thus, the two main groups of transformations to be investigated should be concentrated on the following development patterns:

The *first* group of *external* transformations is linked with the disappearance of non-market production activities or, alternatively, with the integration of non-market production into the evolving market network. Using a closed sectoral classification scheme by introducing six main market-sectors, namely agriculture, industry, firm-related services, household-related services, the public sector, and an environmental complex of waste disposal and re-cycling,[17] processes of external absorptions or integrations[18] can be studied by concentrating on peripheral or semi-peripheral forms of integration, by focusing on sectoral integration types, by investigating large-scale pre-market production units and small ones, etc.

The *second* group of *internal* transformations is concentrated on the endogenous changes within the evolving market network of market-networks. Sticking to the same sectoral scheme as above, the main focus here lies in then internal sectoral predator-prey dynamics like the marginalization of agriculture in the past, the marginalization of industry in the future, the increasing importance of firm-related services, past and present, etc. [19]

From here, a rich field of epigenetic analyses can be built up since the sectoral categorization schemes offer a relatively high degree of functional homogeneity and can be supplemented with a number of evolutionary important characteristics like the shape of sectoral life-cycles, minimal and maximal diffusion potentials, main processes of sectoral differentiations and the

---

[16] At this point, the parallels between John H. Holland and Karl Polanyi can be completed by referring to Polanyi 1978: 112.

[17] On these sectors and their precise definitions, see esp. Müller and Haag, 1994.

[18] See also the interesting term of "Landnahmen" which has been used by Burkard Lutz, 1984.

[19] Here, the processes of *"Landnahmen"* or, alternatively, of "sectoral subsumptions" is clearly understood, contrary to Burkart Lutz (1984), as an *ongoing* characteristic of economic development. Due to the *permanency* of sectoral "predator-prey" relations, no fixed points or attractors are in sight which, after a long time of revulsions and revolutions, can guarantee a *stable* sectoral distribution like in the case of Fourastie's phase transition from 80% agriculture, 10% industry and 10% services to 10% agriculture, 10% industry and 80% services ... On useful formalisms in the area of predator-prey modeling, see Hofbauer and Sigmund, 1984 or Peschel and Mende 1986.

like. Moreover, the permanent recombinations and adaptations within this market-network of market-networks ... of market-networks have accumulated a rich and diversified "market memory", whose selection and learning procedures in the past must be seen as essential constraints or "lock-ins" for selection- and learning-habits in the future ...[20]

What makes the epigenetic transfer module on network ensembles particularly interesting, lies in the emphasis of the co-evolutionary character of development. Thus, an accompanying system must be introduced which has been characterized, following the *spirit* of Karl Polanyi, as "societal protective belt". The rationale for the introduction of a global, national or regional protective belt aside from a global, national or regional market-web, lies in the specific role which has been assigned to the protective belt. It acts as a "compensatory mechanism" (Offe, 1971) which guarantees the sustainability, i. e. the long-term reproduciability especially of two production factors, namely of labor and land or, more generally, of the environment. Polanyi's main-argument for the co-evolutionary essential role of a societal protective belt comes from the *non*-sustainable nature of market expansion, since, following Polanyi, a self-regulating market cannot be sustained without destroying the human potential or the state of the environment. (Polanyi, 1978: 19 p.) Thus, one has arrived at the core of Polanyi's co-evolutionary macro-societal vision –

> for centuries ... the dynamics of modern society has been determined by a double movement. Markets expanded continuously, but this expansion remained dependent on protective institutions which facilitated this expansion in certain directions.[21]

[20] For more details, see especially Müller and Pichelmann, 1990: 174 ff.

[21] The translation has been provided by Karl H. Müller, taking the quote from Polanyi, 1978: 182.

Table 3: The Evolution of Actor-Networks in the Protective Belt $\{TM_{IIa}\}$

ESSENTIAL MARKET-COMPONENTS	PROTECTIVE ORGANISATIONS	MARKET-FUNCTION	PROTECTIVE FUNCTION
CAPITAL	Research & Development Entrepreneurial Interest Groups et al.[22] State Insurance Systems and Guarantees for Enterprises Non-Profit-Sector	Proliferation of New Market Niches; Organisation of Existing Market-Relations Safeguards against Natural or Socio-Economic Risks	Protection of Entrepreneurial Ensembles; Protection from (Un)-intented Consequences of Market Developments or of Environmental Hazards
LABOR	Households Labor-Related Interest Groups et al. Consumer-Interest Groups	Availability and Organisation of-Human Labor	Protection of a Sustainable, Socially Integrated Labor-Force
LAND	Environmental Interest Groups et al.	Availability and Organisation of Natural Resources	Protection of a Sustainable Environment
SOCIETAL SYSTEMS	Corporatist Systems Education and Training Systems Legal System Government and Administrative Systems Societal Self-Organization Building (Citizen-Movements, "Communitarianism", "Civil Society", etc.)	Organisation of the Equilibration of Interests; Societal - Cost-Reduction; Administrative and Political Coordination and Monitoring	Protection of the Three Factors of Production; Protection of the Societal System from (Un)-Intended Market-Consequences

[22] The addendum *et al.* in all of the left hand columns refers to the growing number of intermediate institutions (on this point, see, e. g., Ware 1989).

Consequently, following Polanyi, a co-evolutionary protective belt has a triple role as a constraint in the market expansion, as a co-determinative factor for future market development *and* as an essential safe-guard for the sustainability of market growth. These embedded network formations of the societal protective belt have been built up in a variety of societal networks, extending from labor-related organizations like labor unions, consumer agencies, state insurance systems like those against unemployment or labor-accidents to legal restrictions like the abolishment of child-labor or to a diversified system of transfer payments (Polanyi, 1978: 243).

Thus, at different spatial levels like the urban, regional, national, international as well as global levels one can observe the *co-evolution* of a rich and diversified system of protective actor networks whose relative degree of power and intervention potential plays a significant role for market expansion.

A summary of essential components in the protective belt is presented in Table 3, focusing on the triple function of the protective complex, namely safe-guarding a self-perpetuating market network from the unintended as well as from some intended consequences of the market expansions, co-directing the "drift" of market expansion and, finally, safe-guarding the continuation and, thus, the potential sustainability of market growth in the long foreseeable future. The advantage of such a scheme lies primarily in its co-evolutionary perspective, relating the development patterns in the protective belt to the expansions and contractions in the market networks — and *vice versa*.

2.2. THE CO-EVOLUTION OF DISCIPLINARY AND TRANSDISCIPLINARY PROGRAMS

Turning to the knowledge pools of modern societies, it becomes interesting to note that from the 19^{th} century onward a parallel process of co-evolution can be recorded especially within the scientific knowledge bases, taking the evolution of scientific disciplines and their program production as its major "engine of growth" and the proliferation of inter- or transdisciplinary programs as its protective counterpart.

From an epigenetic point of view, the central characteristic of disciplinary programs in science and technology can be specified in the following manner. Scientific programs within a large number of disciplines can be considered as widely distributed ensembles at the code levels, exhibiting a core reproduction requirement (average program growth rate of a specific discipline), comparative advantages via cognitive program innovations (opening up new topics, new theories, new methodologies or new data) as well as, finally, a self-organizing mode of expansion far from "cognitive equilibrium". Even in the long run, the cognitive drift within the scientific program pools will not be directed, despite claims to the contrary, towards a global attractor.[23] More precisely, one can list several main characteristics of a self-organizing disciplinary program proliferation and organization within the science system.

First, the scientific pool of disciplinary programs can be conceptualized as a collection of autonomous units or "building blocks" of various types, ranging from sub-program entities to programs, clusters of programs, "themes" and "metaphors", subdisciplines, disciplines, clusters of disciplines, etc. Moreover, these building blocks are interlinked in a number of ways, from citations and the local environment of their production to logical relations and methodological structures.

Second, no global control-systems can be identified which would act as a decisive and central steering unit for newly emerging or traditional disciplinary knowledge pools. More specifically, no global control units at the network levels act as decisive gate and distribution keepers which control the scientific program proliferation across various desciplines.

Third, disciplinary programs exhibit a high variety and stratification, both at the horizontal and at the vertical dimension. Especially for the vertical dimensions, grand vision of scientific "unification" or "reduction" from the social sciences to psychology and cognitive sciences to life sciences and, penultimately, to physics demonstrate the high vertical interlinkedness of the scientific program pool. And with respect to horizontal density, one can observe a rich variety of different disciplines within a well-defined domain. Take human cognition as a primary example, then one will find even at the same horizontal level of adaptive human behaviour significant contributions from artificial intelligence, cognitive science, artificial live, education science, social psychology, sociology, anthropology and the like.

Fourth, a high degree of program *recombinability* and *adaptability* guarantees, *inter alia*, a high potential for cognitive innovations both in fundamental, but also in marginal ways.

Fifth, frequent processes of disciplinary differentiation and specialization or, alternatively, the gradual and, at times, sudden appearance of new disciplinary programs imply the disappearance of "universal" program building blocks or a universal paradigm, being able to fit into *any* cognitive disciplinary niche.

Sixth, one can observe a continuous opening up of or, very seldom though, a closing down of cognitive niches.

[23] "Cognitive equilibrium" is to be understood in Stephen Hawking's terms of a final theory state which, for cognitive reasons, remains in a stable state. (On this point, see Hawking, 1988)

Seventh, no global optimum can be specified for the scientific program development as well, leading, thus, to a very long-term process of program self-organization without limits and inner boundaries.

According to this self-organizing view for the code-levels, the main processes to be investigated lie in the *great transformations* of a comparatively small modern knowledge base at the beginning of the 16th century to an all-encompassing, highly integrated knowledge pool of knowledge pools at the end of the 20th century. Thus, the two main groups of transformations to be investigated should be concentrated on the following development patterns:

The *first* group of *external* transformations is linked with the disappearance of alternative knowledge traditions or, alternatively, with the integration or, more adequately, the subsumption of other knowledge cultures into the evolving modern science pools. Using a closed science classification scheme by introducing three main science-sectors, namely natural sciences, technology and medicine as well as social sciences, processes of external cognitive absorptions can be studied by focusing on special integration types, by investigating groups and clusters of external knowledge traditions, etc.

The *second* group of *internal* transformations is concentrated on the endogenous changes within the evolving discipline formations. Sticking to the same disciplinary scheme as above, the main focus here lies in the internal absorptions like the marginalization of theology or philosophy from the 18th century onward, the marginalization of physics in the future, the increasing importance of life or eco-sciences, past, present and future, or of the emerging fields related to computer and information processing, etc.

From here, a rich field of epigenetic analyses can be built up since the disciplinary categorization schemes, aside from offering an evolutionary stable classification, exhibit a relatively high degree of functional homogeneity and can be supplemented with a number of evolutionary important characteristics like the shape of disciplinary life-cycles, minimal and maximal diffusion potentials, main processes of disciplinary differentiations and the like. Moreover, the permanent recombinations and adaptations within this disciplinary ensemble of disciplinary programs ... of disciplinary programs have accumulated a diversified "disciplinary memory", whose selection and learning procedures in the past must be seen as essential constraints or "lock-ins" for selection- and learning-habits in the future ...

What makes the particular epigenetic transfer module on code-levels ensembles particularly interesting, lies in the emphasis of the co-evolutionary character of program development. Thus, an accompanying system can be introduced which can be characterized as transdisciplinary and fulfills the essential role of a "cognitive protective belt". The rationale for the introduction of such a transdiscipiinary ensemble at the program levels aside from a disciplinary web, lies in the specific role which has been assigned to this transdisciplinary program group since it guarantees and safeguards the sustainability, i. e. the long-term reproduciability of the overall disciplinary program pool. The main-argument for the co-evolutionary essential role of a cognitive "protective belt" comes from the *non*-sustainable nature of disciplinary expansion, since a self-regulating system of scientific disciplines cannot be sustained without destroying the cognitive potential or the cognitive transfers to non-scientific societal segments.

Table 4: The Co-Evolution of Transdiscipiinary Programs $\{TM_{IIb}\}$

	TRANSDISCIPLINARY PROGRAMS	DISCIPLINARY FUNCTION	PROTECTIVE FUNCTION
CONTEXT OF DISCOVERY	Inter- and trans-disciplinary programs of empirical nature, from early encyclopedias and thesauri to transdisciplinary model-encyclopedias of the present time	Suggestions for heuristics and methods which can be transformed into the "disciplinary matrices" of single disciplines	Protection from redundancies; Protection from "innovation locks"
CONTEXT OF JUSTIFICATION	Inter- and trans-discipiinary programs of normative nature including evaluation measures for disciplinary programs	Availability of a common set of evaluation criteria for disciplinary research	Protecting the performance of the disciplinary system
PROGRAM ENVIRONMENTS	Programs for "Popularizing Science"	Wider access to new results, "ordering" of disciplinary results	Protecting the acceptance of the scientific knowledge pools

Consequently, a co-evolutionary transdisciplinary belt performs a triple role as a constraint in the disciplinary expansion, as a co-determinative factor for future development within and across disciplines *and* as a safe-guard for the sustainability of disciplinary program growth. These embedded transdisciplinary code formations have been built up in a variety of ways and can be grouped into four main domains, namely into theory, methodology (including formal mathematical or statistical models), data and language. In all four areas, essential tools and instruments are at hand which offer a substantial contribution in linking and combining the wide range of disciplinary programs.

Thus, at different spatial levels one can observe the *co-evolution* of a rich and diversified system of transdisciplinary programs whose cognitive impact plays a significant role for the disciplinary expansion. With Table 4, a second co-evolutionary ensemble, this time at the code levels, has been introduced and conceptualized as a genuine "transfer module".

2.3. THE CO-EVOLUTION BETWEEN ACTOR-NETWORK FORMATIONS AND KNOWLEDGE BASES

In a final move, the notion of "embeddedness" can be taken one step further, postulating "embeddedness relations" not only within the network levels or within the code levels, but across network and code levels as well. Taking a well-known Granovetter quotation as starting point —

> the behavior and institutions to be analyzed are so constrained by ongoing social relations that to construe them as independent is a grievous misunderstanding (Granovetter, 1985: 481 f.) —

one can arrive, *via* a small set of recombinations, at three major embeddedness formations –

> the market operations to be analyzed are so constrained by ongoing relations with the protective belt that to construe them as independent is a grievous misunderstanding ...
>
> the evolution of disciplinary programs to be analyzed is so constrained by ongoing relations of inter- and transdisciplinary nature that to construe it as independent is a grievous misunderstanding ...
>
> the behaviors of actor networks to be analyzed are so constrained by ongoing relations with the knowledge pools that to construe them as independent is a grievous misunderstanding ...

Moreover, from an epigenetic point of view, "embeddedness" between the main dual epigenetic levels can be specified for the three traditional perspectives of social science investigations, namely for micro-, meso- and macro-social analyses respectively. In a general functional perspective across micro-, meso- and macro-levels, the embeddedness of actor networks and knowledge pools exhibits some interesting features, which can be summarized via Table 5.

Here, the core embeddedness function of the knowledge bases in general lies in their "recipe-character" for sustaining the reproduction of network actors, for generating the production of new network units and for shaping innovations at the levels of actor networks. These three core functions can and must be described in fuller detail.

Table 5: The Embeddedness of Actor Networks in Knowledge Bases {TM_{IIc}}

ACTOR NETWORKS	KNOWLEDGE BASES	CORE-FUNCTIONS FOR ACTOR-NETWORKS
Multiple Units at the Micro-, Meso- and Macro-Levels	Multiple Units at the Micro-, Meso- and Macro-Levels	Co-Production of $Units_N$ Co-Reproduction of $Units_N$ Innovations (New Forms of the Production or Reproduction of $Units_N$)

First, the production of new building $blocks_N$ can be considered as *the* vital embeddedness function of knowledge bases. Here, the genetic code-system plays a well-known and an as yet weakly understood core function in morphogenesis. Similarly, new building $blocks_N$ can be co-determined by implicit $routines_C$, by encoded programs in their recipe-function or by machine code programs, again in their recipe function.

The second protective core function lies in the co-reproduction of building $blocks_N$ which can be maintained for all four major layers in the knowledge bases, too. The genetic system, for obvious reasons, assumes a central role for co-determining the production of proteins and cell-metabolism and, thus, for the maintenance of organisms. The neural bases fulfill an essential role in reproducing the operative potential of network actors. Encoded materials serve as an indispensable recipe-function for maintenance and repair in actor networks. Finally, machine codes act as necessary basis for the surface interactions with information and communication technologies.

Third, innovations, i. e. changes or recombinations in the reproduction or the production of building $blocks_N$, are a final vital core protective function of knowledge bases. Again, the genetic pool, due to its recombinative repertoire, acts as a powerful supplier of new recombinations both for reproduction and production. And without specifying more details, innovations in the (re-)production of building $blocks_N$ occur through the recombinative potential of implicit $routines_C$ or through the recombinative power in encoded or machine-based programs.

These three protective core functions of knowledge bases for actor networks assume at times very different architectures, depending on the micro-, meso- or macro-social focus of investigations. Due to the macro-social character of most of the transfer modules within Part II, the subsequent explorations will be undertaken for macro-ensembles alone. Even here, one finds an astonishing number of characteristic embeddedness relations along the vertical epigenetic dimensions. Table 6 reveals some of these vertical embeddedness features.

Table 6: The Embeddedness of Knowledge Bases in Actor Networks {TM_{IId}}

ESSENTIAL NETWORK-COMPONENTS	KNOWLEDGE BASES	CORE-FUNCTION
MARKET NETWORKS	Distributed Pools of Science and Technologyput-, Programs (STP)	Program Bases for Potential In-Withinput or Output-Innovations in Market Networks
	Distributed Pools of Programs on Repair	Program Bases for the Sustainability of Market Networks and Maintenance (RM)
	Distributed Neural Pro-grams for "Implicit" Practices	Program Bases for Co-Activating New or Established Routines of Implicit Nature
	Distributed Pools for ICT-Programs (incl. ICT-Programs on STP or RM)	ICT-Program Bases of ST and RM Programs for Market Networks
NETWORKS OF THE PROTECTIVE BELT	Distributed Pools of Science and Technology Programs (STP)	Program Bases for Potential In-put-, Withinput or Output-Innovations in the Protective Belt
	Distributed Pools of Programs on Repair and Maintenance (RM)	Program Bases for the Sustainability of the Protective Belt
	Distributed Neural Pro-grams for "Implicit " Practices	Program Bases for Co-Activating New or Established Routines of Implicit Nature
	Distributed Pools for ICT-Programs (incl. ICT-Programs on STP or RM)	ICT-Program Bases of ST and RM Programs for the Protective Belt

Following Table 6, four general points deserve special emphasis.

First, one of the noteworthy features of the embeddedness of knowledge pools in actor networks lies in the sheer amount of redundancies, associated which each of the main layers of the program pool respectively. Aside from the well-known redundancies in the genetic layer – *each* cell of an organism contains, by and large, the necessary recipe for its entire construction —, it remains a highly interesting feature that books, articles but also ICT-based programs are "copied" at high rates and widely distributed throughout the various knowledge pools.

Second, one of the most clearly visible characteristics of vertical embeddedness lies in its "degeneracy", which has been defined by Gerald M. Edelman in the following manner –

There is no unique structure or combination of groups corresponding to a given category or pattern of output. Instead, more than one combination of neural groups can yield a particular output, and a given single group can participate in more than one kind of signaling function. (Edelman, 1989: 50)

Transferring degeneracy into a societal embeddedness context, one can easily see that one-to-many as well as many-to-one relations are a highly characteristic element of vertical embeddedness. Here, a single building block at the code levels can be utilized in numerous ways and many building blocks at the code levels may lead to a specific operation at the network levels.

Third, the types of embeddedness relations for market networks and the protective belt formations remain by and large identical, pointing, thus, to the indispensable function of the knowledge bases for the protective belts, too. This point is noteworthy since knowledge based processes have been largely associated with the economic system and not, or not sufficiently, with the networks of the protective belt like the state apparatus, the domains of "civil societies" and the like.

Fourth, three layers of the knowledge bases assume specific roles in the shaping and in the reproduction of actor networks, whereas the gene pool takes on an unspecific role only. While of vital necessity for the creation of network actors, it can be safely assumed that changes in the gene pool are not to be considered an important explanatory element for macro-societal development patterns.

In this manner, a systemic as well as a systematic summary of code-network-embeddedness relations has been completed.

2.4. THREE GROUPS OF "EMBEDDEDNESS FORMATIONS"

At this point, a final summary will be presented, which centers on the notorious notion of "embeddedness" and which will move the three embeddedness formations, presented so far, in a much wider context. In a systemic fashion, embeddedness formations can be separated, following Table 7a to Table 7c, into three independent groups or clusters, namely into vertical and horizontal embeddedness formations, into symmetrically and asymmetrically embedded ensembles and, finally, into a rich and diverse spectrum of embedded micro-, meso- or macro-formations of varying spatio-temporal scales (short-, medium-, long-term/local, regional, global). Moreover, these three groups can be combined, too, leading thus to a large and, evaluated in terms of common social science methodology, uncommon variety of embeddedness formations.

As a starting point, embeddedness formations especially at the actor network levels can be differentiated according to a general power dimension, taking power in an unspecific Weberian sense as

> the capacity to regulate and control the actions of other members of a population and the structural units organizing these members. (Turner, 1995: 75)

> Thus, the set of embeddedness formations can be split into two main power classes, namely into an asymmetric and into a symmetric cluster. Following the above definition, symmetric power relations are characterized by

> the mutual capacity to regulate and control the actions of members of a population and the structural units organizing these mutual regulations and control

> whereas asymmetric power relations assume

> the capacity by some actors of a network to regulate and control the actions of other actors of a network and the structural units organizing these other actors.

Table 7a: Power-based Embeddedness Relations $\{TM_{IIe}\}$

SYMMETRIC EMBEDDEDNESS	ASYMMETRIC EMBEDDEDNESS
Equivalence Relations Compatible Development Potential High Strong Type of Co-Evolution	Dominance Relations Compatible Development Potential Low Weak Type of Co-Evolution

More specifically, three specific comments can be added to Table 7a.

First, equivalence or domination as power relations are to be understood in a rigorous manner, making ample use of the explanatory context, developed in the actual study of specific embeddedness formations. Thus, equivalence relations assume, *very* generally speaking, an explanatory format of the type –

$$P_{EI} = f\,(P_{EI}, P_{EII}) \text{ and } P_{EII} = f\,(P_{EII}, P_{EI})$$

where the explanatory impacts of the performance of ensemble$_i$ on ensemble$_j$ (i,j = 1,2, i $\neq$ j) exhibits similar proportions. In case of a strong predominance of one ensemble over the other, asymmetrical embeddedness relations prevail. Concretely, for asymmetrical relations an ensemble$_i$ must be strongly relevant for the performance of an ensemble$_j$ (i,j = 1,2, i $\neq$ j) while, in turn, ensemble$_j$ remains of small or marginal explanatory impact for ensemble$_i$ only.

Second, the notion of compatible as well as of incompatible development potentials will be dealt with in a more formal fashion within the next chapter. Here, only a small hint will be provided. Compatible development potentials refer to co-evolutionary growth processes, whereas incompatible development potentials are accompanied by one-sided growth processes only or even by mutual co-involutionary trajectories.

Third, symmetric or asymmetric relations can be identified within and across the three traditional social science perspectives, namely between and within the micro-, meso- and the macro-processes of social science studies. Thus, an overall symmetry pattern at the short-term micro level may be accompanied by highly asymmetric medium-term configurations at the macro level, etc.

Another interesting partitioning of embeddedness formations can be undertaken with reference to the "epigenetic square", differentiating between vertical and horizontal forms of embeddedness. Thus, the co-evolutionary ensembles in chapter 2.1 and 2.2 belong to the horizontal group, whereas the formations, introduced in 2.3, belong to the vertical embeddedness class.

Table 7b: Epigenetic Embeddedness Formations {TM_{IIf}}

HORITONTAL EMBEDDEDNESS FORMATIONS (ACTOR NETWORKS ⇔ ACTOR NETWORKS) (CODE SYSTEMS ⇔ CODE SYSTEMS)	VERTICAL EMBEDDEDNESS FORMATIONS (ACTOR NETWORKS ⇔ CODE SYSTEMS)
Homeostatic Coordination	Coordination of Novelty
Sustainability	Creation
Maintenance of Actor Networks	Production of Network Actors
Co-determination of the "Sustainable Drift"	Co-determination of the "Productive Drift"

Three points in Table 7b, associated with the vertical/horizontal distinctions, deserve a closer specification.

> First, vertical and horizontal embeddedness formations are to be differentiated not according to their impact or as variations on the theme of strong ties, weak ties and their inverse strength. Rather, vertical and horizontal embeddedness formations are separated according to their different constitution and architecture. Horizontal embeddedness formations refer to exchanges, interactions, relations or transfers between similar ensembles either at the code or at the network levels, whereas vertical embeddedness formations are concerned mainly with interactions, relations or transfers between code systems and actor networks.
>
> Second, the emphasis on "sustainability" versus "creation" or between "maintenance" versus "production" should be understood in a metaphorical sense only, since for obvious reasons creative constructions and destructions can be found at the actor-network levels, too. But the emphasis here is directed towards the difference with respect to novelty or emergence. Embedded code systems, by their primary function, are the recipe pools for the production of new network elements, either as network actors or network actor network components like socio-technical systems. In a similar manner, the primary function of actor networks lies in their sustainability and their successful continuation.
>
> Third, the two-fold notion of "drifts" – "sustainable drift" and "productive drift" – refer to a well-known property of dynamic systems which has been given various names like "memory effects", "lock-ins", "sensitivity to initial conditions" and the like. All these labels refer to the powerful role of past operations, decisions, routines, relations for available options in the future. Thus, the terms of a "sustainable" or a "productive drift" denote the overall direction or the gradient of intertemporal development patterns with respect to production or reproduction processes.

Finally, Table 7c presents an unusual spatio-temporal differentiation which can be used for socio-economic processes in general. Here, the specification of building blocks both for code sytems and actor networks can be applied, in principle, to 3^2 different spatio-temporal scales for micro-, meso- or macro-societal perspectives. Thus, a micro-building block like an individual or a household can be used for a micro-based analysis of long-term global processes whereas a macro-building block like a science system can be studied at least in its regional short-term development patterns. Taking the subsequent notion of macro-level perspectives as a reference point —

> Macro-level theory focuses on (a) populations that number into the thousands, and usually many more; (b) populations that remain organizationally and culturally coherent in their environment for at least several decades and typically many more;

> and (c) populations that control at least a few thousand square miles of territory and generally much more (Turner, 1995: 1 p.) —

then it is easy to see that societal macro-theory can be undertaken, again in principle, with macro-building blocks at the code and network levels for 3 x 3 spatio-temporal scales (local/regional/global and short-/medium-/long-term).

Again, a symmetrical argument on the multiplicity of building blocks can be constructed for micro-perspectives as well. Recombining the above definition for a micro-level focus, one arrives at the following minimal micro-specifications –

> Micro-level theory focuses on (a) micro configurations that number into the hundreds, and usually much less; (b) ensembles that remain coherent in their environment for at least several seconds and typically many more; and (c) ensembles that can be located in space as well.

Here, micro-perspectives are based on micro-building blocks which, once again, can be used for 3 x 3 spatio-temporal horizons.

Concluding with the societal meso-perspective, it is comparatively easy to construct a homology from micro- and macro-level theory –

> Meso-level theory focuses on (a) meso configurations that number into the thousands, and usually much less; (b) ensembles that remain coherent in their environment for at least several years and typically many more; and (c) ensembles that can be located in space as well.

Consequently, Table 7c exhibits a slightly unconventional summary of micro-, meso- and macro-societal perspectives and, moreover, a large number of possible embeddedness formations.

Moreover, the following specifications can be made which support the scheme of Table 7c on the spatio-temporal boundaries of embeddedness formations.

Table 7c: Spatio-Temporal Embeddedness Formations $\{TM_{IIg}\}$

BUILDING BLOCKS$_{C,N}$

	MICRO-SOCIETAL PERSPECTIVES:		
		Time Horizons	
	Short	Medium	Long-Term
Micro-Level Building Blocks$_{C,N}$			
Local	Field I_{MI}	Field II_{MI}	Field III_{MI}
Regional	Field IV_{MI}	Field V_{MI}	Field VI_{MI}
Global	Field VII_{MI}	Field $VIII_{MI}$	Field IX_{MI}
	MESO-SOCIETAL PERSPECTIVES:		
Meso-Level Building Blocks$_{C,N}$			
Local	Field I_{ME}	Field II_{ME}	Field III_{ME}
Regional	Field IV_{ME}	Field V_{ME}	Field VI_{ME}
Global	Field VII_{ME}	Field $VIII_{ME}$	Field IX_{ME}
	MACRO-SOCIETAL PERSPECTIVES:		
Macro-Level Building Blocks$_{C,N}$			
Local	Field I_{MA}	Field II_{MA}	Field III_{MA}
Regional	Field IV_{MA}	Field V_{MA}	Field VI_{MA}
Global	Field VII_{MA}	Field $VIII_{MA}$	Field IX_{MA}

Embeddedness within the *micro*-perspectives between and within knowledge bases and actor networks: Here, actor network building blocks from traditional micro-sociology – individuals, small groups, households, families, but also sub-individual units of the "multiple self variety" (Coleman, 1990, Elster, 1986, Giddens, 1991, Müller, 1998b), will become in most cases the essential building blocks for the network levels, whereas the neural bases of "tacit routines" as well as the encoding and decoding practices become quintessential parts of the four remaining epigenetic dimensions. These embeddedness formations can be analyzed across different space-time horizons, although the main emphasis will be devoted to short-term local processes and, due to aggregation and measurement problems, hardly, if at all, to long-term global processes.

Embeddedness at the *meso*-perspectives between and within knowledge bases and actor networks: Since meso-social ensembles are normally associated with small-, medium- and large-scale organisations or collective actors like unions or associations, the epigenetic research perspective asks for an appropriate structuring of these meso building blocks, conceptualizing them as dual level evolutionary units, consisting of a set of actor network building blocks and, depending on the choice of specific network units, of a corresponding knowledge pool. Again, 3^2 different embeddedness formations are, in principle, open for meso-investigations.

Embeddedness at the *macro*-levels between and within knowledge bases and actor networks: Finally, a third type of spatio-temporal embeddedness formations can be identified at the macro-levels, linking large-scale societal ensembles like the scientific-technological system, the political-administrative system, the economic system, the cultural and artistic system, the "civil society" (including mass media) or other macro-ensembles in their actor network formations *and* their specific knowledge bases. Here, the main emphasis will lie in long-term regional, preferably national, or global horizons, excluding almost by terminological necessity, local short-term interactions.

In this manner, an encompassing and far-reaching transfer module on the large number of ways for embedding embeddedness relations has been completed.

3. A TRANSFER MODULE FOR "EMBEDDED KNOWLEDGE LOOPS" IN MODERN SOCIETIES

Shifting from a general co-evolutionary perspective to time-dependent patterns of "double movements", a small class of new concepts and definitions has to be introduced which will be followed by a new type of transfer module on "embedded vertical knowledge loops" in modern societies.

3.1. COMPATIBLE AND INCOMPATIBLE DEVELOPMENT POTENTIALS: BASIC DEFINITIONS

As a starting point, a morphological space will be opened up which will distinguish between compatible and incompatible interactions between two large-scale ensembles of knowledge societies (KS-E) within or between code and network levels.

Following Table 7c, the long-term co-evolutionary movements between essential societal ensembles are confined to self-organizing markets and protective belts at the network levels, to disciplinary and transdisciplinary programs at the code levels and to actor networks and knowledge bases between code and network levels. These double movements can be classified into three major types, namely into strongly compatible, into weakly incompatible and into strongly incompatible forms of co-evolution.

In a formal mode of operationalization, *strongly compatible* co-developmental potentials require the following constellation -

$$(\partial E\ I_t/dt \geq 0) \wedge (\partial E\ II_t/dt \geq 0)$$

i. e., an above average growth and development process must occur in both knowledge society ensembles (E I and E II), when evaluated in terms of core performance indicators for each of these two assemblies.

Table 8: Interaction Space between Two Embedded Ensembles {TM_{IIIa}}

		ENSEMBLE-GROUP I	
		ABOVE AVERAGE DEVELOPMENT POTENTIALS	BELOW AVERAGE DEVELOPMENT POTENTIALS
ENSEMBLE-GROUP II	ABOVE AVERAGE DEVELOPMENT POTENTIALS	Type I	Type II
	BELOW AVERAGE DEVELOPMENT POTENTIALS	Type III	Type IV

The notions of "above average" and "below average" in Table 8 refer to the long-term global velocity of actor network or knowledge growth, i. e. to the weighted averages of core performance indicators for actor networks (GDP per capita, etc.) or program production (Science Citation Indices (SCI), etc.). More precisely, a well-defined space-time unit like a nation within a specific time interval (for example between 1950 and 1970) exhibits a strongly compatible development potential if and only if the growth in, say, the market networks (E I) and in the protective belt (E II) are above the average growth rates globally. Thus, the welfare state model between 1945 and 1973 throughout the OECD member states exhibits at the network levels clearly all essential characteristics of a *compatible* co-evolution, showing strong growth rates in market performance indicators like GDP or exports and a marked expansion in the performances of the protective belt, especially of network formations in the public domain. Moreover, the growth rates for most of the OECD countries were situated above the average global growth rates in this period, fulfilling, thus, the criterion of strong compatibility. Consequently, growth rates above or below zero have to be understood with reference to the global velocities of the modern world system and not simply to the absolute values.

Weakly incompatible development potentials exhibit *one* of the following two configurations—

$$(\partial\, E\, I_t/dt \geq 0) \wedge (\partial\, E\, II_t/dt \leq 0)$$

$$(\partial\, E\, I_t/dt \leq 0) \wedge (\partial\, E\, II_t/dt \geq 0)$$

that is, a significant development process in *one* of the societal ensembles must be accompanied by relative declines in the other ensemble, again assessed by core-performance indicators for both ensembles. Here, special emphasis must be given to the term "relative decline" since a global growth rate of, say, 1.5% in market networks and 1.2% in the networks of the protective belt leaves ample room for above and below average variations with positive absolute growth rates in both societal ensembles.

Finally, *strongly incompatible* developmental potentials are of the form —

$$(\partial\, E\, I_t dt \leq 0) \wedge (\partial\, E\, II_t/dt \leq 0)$$

where involutionary processes are characteristic for both societal ensembles when measured in terms of core performance indicators. An important point must be added, again. Due to the reference points of long-term global growth and expansion rates, strongly incompatible processes are not necessarily linked to absolute declines. Over the long run though, a constant below average growth potential simply must follow an involutionary trajectory in which the comparative disadvantages of backwardness are clearly inhibiting any "catching up" processes or "big spurts".

3.2. THE BASIC ARCHITECTURES OF "EMBEDDED KNOWLEDGE LOOPS" IN MODERN SOCIETIES

With the definitions introduced above, an interesting distribution of four basic formations of modern "knowledge societies" can be achieved. Basically, these four types can be directly linked to the dimensions of the epigenetic square and to essential performance indicators for each of these dimensions.

> On the one hand, the performances along the five epigenetic dimensions can be interlinked in a uniform manner, yielding a high degree of positive correlation throughout these dimensions when evaluated in terms of substantial performance indicators.
>
> On the other hand, the relations between the performances on these five epigenetic dimensions can be coupled in a significantly negative form, exhibiting high (low) values for the actor network levels and low (high) values for the three code-related dimensions, i. e. the encoding, the decoding and the program dimensions.

Moreover, since the basic characteristic feature lies in the type of embeddedness of a societal "knowledge base" within its actor-network formations, the notion of "embedded knowledge loops" has been employed.

Table 9: Four Types of "Embedded Knowledge Loops" in Modern Societies $\{TM_{IIIb}\}$

	TYPE I	TYPE II	TYPE III	TYPE IV
$C \Leftrightarrow C$	+	-	+	-
$C \Rightarrow N$	+	-	+	-
$N \Rightarrow C$	+	-	+	-
$N \Leftrightarrow N$	+	+	-	-
$C \Leftrightarrow N$	+	+	-	-

More concretely, these four basic architectures for modern knowledge societies, past and present, can be described in the subsequent way.

Positively embedded positive knowledge loops: Type I consists of those instances with high performances both at the code and at the network levels. It must be stressed that strong growth processes simultaneously across the five epigenetic dimensions should be considered from a *global*, long-term point of view as relatively infrequent events to be identified within a single region or nation. A paradigmatic Type I configuration occurs during successful science and technology driven "catching up processes" like in the case of Germany between 1850 and the turn of the century.

Positively embedded negative knowledge loops: Type II can be identified in those arrangements where, on the one hand, basic overall code-level indicators like TBP, the technology balance of payments or general SCI-indicators rank significantly below the OECD average and where, on the other hand, overall network-level performance indicators like GDP growth, rate of unemployment, per capita income and the like are situated comfortably superior to the OECD averages. Taking Austria after 1945 as a typical case in question, the TBP share amounts to 28% only and the SCI-values are situated well below the OECD averages, whereas unemployment is still to be considered as relatively low and annual GDP growth for the last thirty or forty years clearly above the OECD averages (Felderer, 1996). Moreover, the second type poses, aside from an insufficient "knowledge base", a considerable "free rider" problem, reaping the high and medium technology benefits without an appropriate R&D investment in high and medium technology segments.

Negatively embedded positive knowledge loops: Type III, then, comprises a strong position across the code levels, above all within the encoding or decoding dimension, while being comparatively weak in actor-network performances. With the United Kingdom as typical example, one sees here a problem of an inadequate network level knowledge diffusion since barriers at the network levels prevent a higher return on R&D investment and a more successful propagation and diffusion of the three fundamental P's at the code levels — programs, patents and prototype programs — at the market network domains.

Negatively embedded negative knowledge loops: Finally, Type IV is to be seen as the reference case in many peripheral regions of the modern world system where both code level and network level performances remain at a low or even a depressed state. Here, it seems advisable to classify the resulting overall constellation as a compound "code-network under-utilization". For Type IV, potential "catching up" processes are in danger of running into code level bottlenecks or network level shortages simultaneously.

4. A TRANSFER MODULE ON POTENTIALLY SUSTAINABLE AND U-SHAPED CO-EVOLUTIONARY MOVEMENTS: HOMEOSTASIS WITHIN THE MODERN WORLD SYSTEM

The discussion on predominant development patterns within global, national or regional knowledge societies can be carried a step further by asking for predominant evolutionary patterns between and across actor networks and knowledge bases. Given the self-organizing character of all four major ensembles – market networks, disciplinary programs, networks of the protective belt, transdisciplinary programs -, it becomes possible to introduce a well-known coordination mechanism, namely homeostatic coordination which, by now, has established a long and successful history within physiology or within the life sciences in general (Ashby, 1974, 1981, Bertalanffy, 1968:160pp., von Foerster, 1957; and as a recent perspective, Casti, 1992 and Rosen, 1991).

Without going into the details of the variety of homeostatic mechanisms, six general points can be established.

> First, the underlying homeostatic coordination for societal ensembles is a dual configuration, consisting of expanding market network formations and an ensemble for coordination/integration/regulation/repair which, however, is of comparatively smaller complexity only. Moreover, this homeostatic architecture has very many degrees of freedom since a large number of self-organizing coordinators/ integrators/ regulators/ repairers – the ensembles of the protective belts or of transdisiciplinary programs – operates on a self-organizing assembly of market network of market networks or on a vast range of disciplinary programs.

Second, the domains or "goals" for coordination are of a hyper-complex nature, being a composite goal domain of multi-dimensional goal domains.[24] In addition, the spatio-temporal architecture of the homeostatic coordination reveals a large amount of different local, regional, national or international levels with differing time scales as well.

Third, both homeostatic ensembles are growing and adapting entities, which adds another facet to the hyper-complex nature of the resulting coordination and steering configurations. In other words, both ensembles are highly flexible and changing over time. Finally, market networks have reached rather early, following Table 1, a self-organized cyclical development pattern of "long swings", associated with the diffusion of basic product innovations in core production and infrastructure or, as a recent achievement, in service domains.

Fourth, *the* important requirement for a continuous homeostatic coordination lies, following Ross Ashby, in the "requisite variety" of the protective network belts or of the transdisciplinary program side. In other words, a homeostatic coordination requires a sufficient degree of coordination/integration/regulation/repair-capacity in order to fulfill its main functions and tasks.

Fifth, both homeostatic ensembles are characterized by an unusually wide internal and external substitution potential. Internally, the various components of the protective belt may take on a very large state apparatus and a high level of private expectation on state coordination like in Italy or in Austria or, alternatively, of a relatively downsized political-administrative apparatus, corresponding low expectation levels for state coordination and a high level of societal self-organization like in the United States. Externally, a surprisingly large amount of societal performances – education health, unemployment services, security, transport and infrastructure, arts and culture, universities, etc. — can be organized either as market networks or as protective belt formations. Taking "Darwin's dangereous ideas" (Daniel C. Dennett, 1995) seriously, each city, region, nation at present ... can be considered as the long-term result of innumerous decisions and operations, based on comparative advantages, which have led to a unique combination of market formations and protective belts.

Sixth, in the homeostatic societal arrangement just outlined, major systemic failures occur, by necessity, for two general reasons. On the one hand, the "engines of growth" – market networks or scientific disciplines – generate too much diversity

[24] To be more precise and concrete, the goal set for the network levels alone consists of the functional domains, specified in Table 8, namely of capital, labor, environment and society where each of these functional domains can be characterized by a multi-dimensional set of critical target domains.

which cannot be accomodated for by the coordinating/integrating/regulating/repair ensembles – the protective belt and transdisciplinary programs. On the other hand, the coordinating ensemble produces too much coordination/integration/regulation/ repair output, leading to a reduction in the performances of market networks or of scientific production.

Consequently, co-evolution or Polanyi's "double-movement" in a homeostatic manner leads to a simple typology of classes of intertemporal trajectories within an elementary C-N phase space. A "bold typological conjecture", based on this phase space, stresses, above all, two general long-term and U-shaped trajectories within actor network levels, within the code levels and, finally, between code and network levels which can be clearly qualified as non-sustainable in a strong sense, since they undermine even the relative successes, accomplished in one of the major societal domains.

In greater detail, the following three classes of co-evolutionary paths can be identified for special ensembles within or across the network and code levels:

mutual re-enforcement — a self-propagated development process with positive feedbacks

U-turns — a one-sided growth process, followed by a significant U-turn

Mutual involution, a self-propagated development process of relative decline with negative feedbacks.

Table 10: Potentially Sustainable Development Trajectories — and Two Essential U-Turn-Patterns $\{TM_{IVa}\}$

E I+/E II+	TYPE I	(POTENTIALLY SUSTAINABLE, CO-EVOLUTIONARY UPWARD MOVEMENTS)[25]
E I+/E II-	TYPE II	(NON-SUSTAINABLE, U-TURNS)
E I-/E II+	TYPE III	(NON-SUSTAINABLE, U-TURNS)
E I-/E II-	TYPE IV	(NON-SUSTAINABLE, CO-EVOLUTIONARY DOWNWARD MOVEMENTS)

[25] "Potential sustainability" implies that trajectories of Type I have the potential of being sustainable, although it seems advisable to distinguish between three groups of sustainable trajectories:

Potential sustainablity – a long-term and compatible development pattern,
Weak sustainability – the global generalizability of a societal ensemble at the urban, regional, national or international levels,
Strong sustainability – the global generalizability of a societal ensemble at the urban, regional, national or international levels in the very long run.

Diagram 1 offers a general summary of the "U-turn conjecture" for three major configurations of the phase spaces for actor-networks formations and knowledge bases. With respect to the three main domains (network levels, code-levels, code-network levels), the grand conjecture on U-turns and fatal homeostatic systems failures assumes the subsequent specifications.

4.1. POTENTIAL SUSTAINABILITY AND U-TURNS AT THE NETWORK LEVELS

The tragedy of the common U-turns both of the Type II and the Type III variety lies in the fact that such reversals undermine the relative position either at the market networks (Type III) or at the network of protective belts (Type II). More concretely, the following four network patterns can be discerned, taking mainly examples from societal evolution in the 20th century.

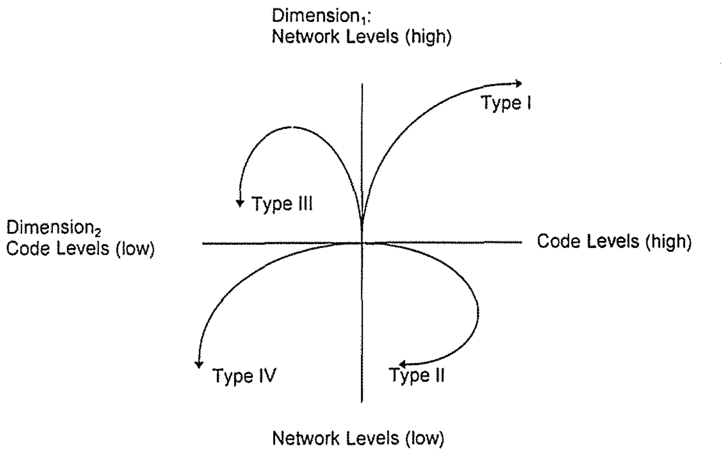
Type I-formations, paradigmatically experienced during the "short dream of everlasting prosperity" (Burkhard Lutz) between 1945 and the early 1970s within the core-regions of the modern world system, exhibit a significant upswing both in market network formations and within the protective belts. Here, the metaphor of "coordination at the edge of chaos"[26] may provide a fruitful hint on the underlying co-evolutionary movements, since both market expansion and growth in the protective belt are undertaken in a self-enforcing, positive feedback manner. Above all, the rapid development of basic new product lines in transportation and infrastructure, of associated service sectors in the banking and insurance complex was accompanied by a growing share of financial flows to and from the welfare state apparatus. Here, the GDP-share of public expenditures showed a marked expansion throughout the core-areas, as summarized in Table 11.

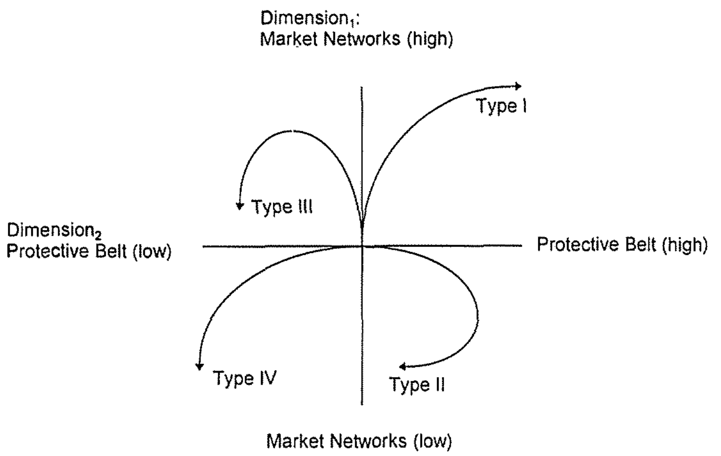
U-turns of Type II are encountered in all those instances and periods during which the control and power potential of the protective belt is unduly enlarged through the "protectorization" of market domains where market networks assume a relatively weak or a marginal position only. Taking Central and Eastern Europe after 1945 as reference point, one finds all sorts of market confinements, ranging from legal restrictions, from organisational limitations to very small units for self-employment up to the emergence of "black markets", "shadow economies", "second economies" and the like. The protective belts, in turn, due to their hypertrophic regulation and coordination potential, underwent a rapid process of centralization and fragmentation which can be considered as the most decisive contributing factor for the resulting overall U-turns both in market network formations and in the development of the protective belts.

---

[26] On the metaphor "life at the edge of chaos" and the underlying models, associated with it, see especially Langton, 1989, 1994.

Diagram 1: The Great Conjecture of Co-Evolutionary U-Shaped Development Trajectories in Three Domains (Code⇔Network Levels, Network Levels, Code Levels) {TM_{IVb}}





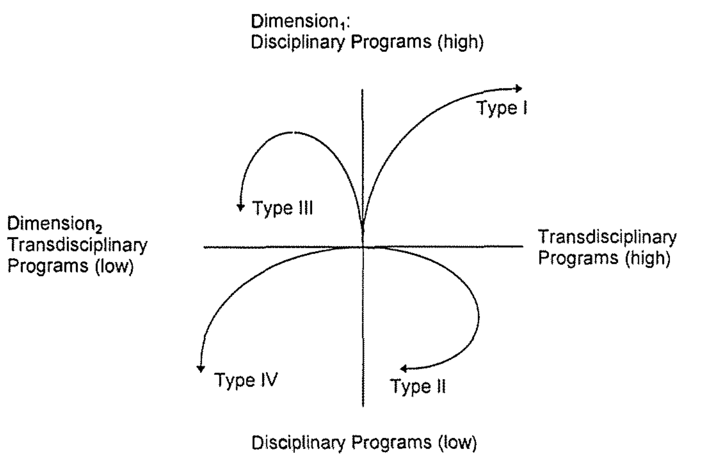


Table 11: Development of the GDP-Share of Public Expenditures and Transfers 1950–1970[27]

	Share of Public Expenditures (% of GDP)		Share of Transfers (% of GDP)	
	1950	1970	1950	1970
Austria	25,0	40,3	7,8	13,9
Belgium	26,3	40,3	9,6	18,9
Canada	26,8	41,2	5,8	10,4
Denmark	19,4	47,5	5,8	15,0
Finland	26,9	37,2	5,8	8,8
France	28,4	42,4	11,3	20,0
Germany (West)	30,8	45,6	12,4	16,7
Italy	27,8	43,1	9,3	19,6
Netherlands	27,0	54,3	6.6	26,1
Norway	25,5	46,5	4,9	16,0
Sweden	37,5	51,0	6,3	16,6
Switzerland	20,8	27,4	5,9	10,2
United Kingdom	30,4	46,1	5,7	11,1
United States	27,4	36,2	5,8	10,4

Needless to say that societal trajectories, after a complete U-turn of Type II, start to follow along a Type IV-path in which both market networks and the networks of the protective belt are entangled in a co-evolutionary relative downward movement.

Type III-U-turns occur whenever the development of market networks moves significantly beyond the coordination and regulation potential of the protective belts. A paradigmatic example for this type of coordination failure lies in the experience of those "market shock therapies" (Central and Eastern Europe after 1989, Chile, etc.) where an all-exclusive emphasis is placed on market network development without a corresponding account of generating the appropriate societal protective belts of requisite variety. Here, again, U-turns, undermining the relative successes of market expansion must or, less emphatical, should be the overall process result.

Type-IV co-evolutionary movements exhibit a configuration in which both market-networks and the protective belts become mutually marginalized. Since the reference frame for both development trajectories lies in the long-term global velocity, Type IV-processes are still the predominant developmental configuration in those areas, associated with the "Fourth World". Here, a mutually self-enforcing interaction pattern can be observed between small market networks and small protective belts which are both embedded in largely traditional and, above all, stationary settings. Following the spirit of Polanyi's work, Type IV can be associated with another instance, too,

[27] For sources, see Flora and Heidenheimer, 1984: 310 pp. and Müller 1988: 362.

namely with the development of National Socialism especially after 1936 where, after a short period of crippling the labor-related protective belts, of the democratic organisational settings and of "boosting" the market formations from 1933 to 1936, a development path set in which was at the same time a de-marketization of self-organizing market networks, a de-protectorization of the protective belts (political and legal system, science, culture ...) and a unique power concentration for a single political party.

In this manner, a short summary of four essential co-evolutionary actor-network formations has been provided which should serve as a useful heuristic transfer module.

4.2. POTENTIAL SUSTAINABILITY AND CO-EVOLUTIONARY U-TURNS AT THE CODE-LEVELS

While it has become comparatively easy to identify important instances of societal U-turns at the network levels, a corresponding code-level pattern is difficult to detect at best. It might even be argued that the self-organization of a discipline based science system, arranged as a "homeostatic complex" from its starting points in the mid-18th century onward, has successfully overcome any severe barriers, characteristic for U-turn trajectories. Here, clearly recognized deficiencies either in the disciplinary segment or in the transdisciplinary realm have induced additional search processes and have lead, thus, to a successful system of coordination and regulation. Nevertheless, two interesting points may be recorded.

First, U-turns in the realm of actor-network formations are at the same time periods in which the knowledge bases undergo a severe period of crisis, too. Take, for example, the development in the knowledge pools of Central and Eastern Europe after 1945, then it is hardly difficult to see a very strong program component within the transdisciplinary ensemble ("dialectical and historical materialism") which imposed very direct and strong restrictions and limitations on the disciplinary program production. Boldly generalized, periods of high power concentration in the protective belts of a clearly non-sustainable nature are, at the same time, phases of strong and equally non-sustainable transdisciplinary program production as well.

Second, the high period of disciplinary expansion within the core knowledge bases during the 1960s and 1970s has produced a number of instances where new disciplines have been organized without a corresponding well-defined program profile.[28] Take the case of small social science subdisciplines, then one can easily see that their emergence has produced, above all, redundancies and has

---

[28] As an extremely interesting point in question see the emergence of a "sociology of technology" (Techniksoziologie) or of a "history of technology" (Technikgeschichte) where even a representative reader states in its introductory pages that this sub-discipline must be characterized as organization-driven only, having established an organizational infrastructure without a corresponding cognitive program of its own (Hausen and Rürup 1975: 19).

contributed, following the Rescher criteria of closed and open knowledge states (Rescher, 1982), to a decrease in the level of perceived knowledge.

Generally speaking though, the co-evolution within the knowledge pools, especially within the proliferation of scientific programs, has been accomplished, so far, in a sufficiently homeostatic and coordinated fashion, generating at the same time a large amount of disciplinary diversity and a sufficient degree of transdisciplinary coordination and coherence.

4.3. POTENTIAL SUSTAINABILITY AND CO-EVOLUTIONARY U-TURNS BETWEEN CODE AND NETWORK LEVELS

In a third summary of long-term double-movements between knowledge pools and actor network formations, the main emphasis will lie on the underlying processes which may induce a U-turn between knowledge base and actor network formations.

With respect to U-turns of Type II, "brain drain" can be considered as the primary force which leads to a relative decline in science network capacities both in quality or in quantity. Due to the overall shortages and constraints within the actor network domains, the scientific technological networks will undergo substantial reductions as well which should express themselves in a considerable brain drain to other core knowledge domains and, thus, in a gradual weakening and decline of the indigeneous knowledge pools. Table 19 cites as primary example the United Kingdom where, as a "grand conjecture", the still highly advanced knowledge bases should undergo a period of relative decline as well.

For U-turns of Type III, non-sustainability may occur through constraints and bottlenecks resulting from limitations of imports as R&D substitution, of free riding, of imitative learning, etc. Due to the high amount of substitution as well as due to the "comparative advantages of relative backwardness" (Alexander Gerschenkron), Type III-U turns are hard to come by. Nevertheless, in periods of "science based economies" and "knowledge as a primary factor of production", the barriers for importing high-level technologies and "embodied" technological advances as well as the limitations inherent in a weak indigeneous science and technology transfer system are the main contributing factors for a gradual U-turn for the network levels as well. Thus, regions with a high network performance but a clearly inferior status in areas like the technological balance of payments should move, so the upshot of the U-turn conjecture, along a path of relative network decline as well.[29]

[29] It must be added though that the U-turn conjecture only precludes a continuous and long-term co-evolution of persistently high network and low knowledge based performances and *vice versa*. It does not preclude the possibility of a science-based "catching up" process for Type III configurations or a rapid improvement in network performances for Type II ensembles.

Table 12: Potential Sustainability and U-Turns in Modern Actor-Network Formations {TM_{IVc}}

Co-Evoiutionary Self-Reinforcing Movements of Type I:

	Market Networks	Protective Belt
Type of Development	Strong Expansion of Market Networks by a New Wave of Basic Product Innovations; Compatible Linkages to the Protective Belt	Strong Expansion in the Networking Capacities of the Protective Belt Compatible Linkages to Market Networks
Historical Instance: Welfare State in Core Regions 1945-1973	Transport Revolution (Cars and Airplanes) as "Leading Sectors"	Emergence of the Welfare State, Extending the Capacities of the "Caring State" (Health, Education, etc.)

Co-Evolutionary U-Turns of Type II:

	Market Networks	Protective Belt
Type of Development	De-Marketization of Economic Networks Incompatible Linkages from the Protective Belt	Dominance of Networks- the Protective Belt Incompatible Linkages to Market Networks
Historical Instances: Central and Eastern Europe between 1945 and 1989	Marginal Role of Legal Market Network Formations; Black Markets, Shadow Price Formation, etc.	Concentration of Power within the Protective Belts; Legitimiation Crises, etc.

Co-Evolutionary U-Turns of Type III:

	Market Networks	Protective Belt
Type of Development	Strong Expansion of Market Networks Incompatible Linkages to the Protective Belt	"Marketization" of the Protective Belt Incompatible Linkages from Market Networks
Historical Instances:	Market-led Catching-up Processes in Peripheral Regions	Weakening of the Protective Belt

Co-Evolutionary Movements of Type IV:

	Market Networks	Protective Belt
Type of Development	Growing De-Marketization of the Economic Sphere, Incompatible Linkages from the Protective Belt	Gradual Dissolution of the Protective Belts Incompatible Linkages from Market Networks
Historical Instances:	Main Development Patterns for Peripheral Regions (Large Parts of Africa, 1970–2000)	Main Development Patterns Peripheral Regions (Large Parts of Africa, 1970–2000)

Table 13: Potential Sustainability and Co-Evolutionary U-Turns in Modern Knowledge Pools

Co-Evolutionary Self-Reinforcing Movements of Type I:

	Disciplinary Programs	Transdisciplinary Programs
Type of Development	Strong Expansion of New Scientific Disciplines	Strong Expansion in Transdisciplinary Problem Solutions
Empirical Instances: Virtual Cycles between Mode I and Mode II	New Forms of Disciplinary Approaches, Linked to Advances in Mode II Programs	New Mode II-Problem Solutions, Linked with Disciplinary Problem Domains

Co-Evolutionary U-turns of Type II:

	Disciplinary Programs	Transdisciplinary Programs
Type of Development	Relative Decline of Disciplinary Program Production	Dominance of Transdisciplinary Programs
Empirical Instances: "Zero-Sum Interaction" between Mode I (-) and Mode II (+)	Change of Disciplinary Programs to Mode II-Programs	Expansion in Mode II Program Production with Problem Solutions in New Domains of Transdisciplinary Character

Co-Evolutionary U-turns of Type III:

	Disciplinary Programs	Transdisciplinary Programs
Type of Development	Strong Expansion of Disciplinary Program Production	Relative Decline of Transdisciplinary Programs
Empirical Instances: "Zero-Sum Interaction" between Mode I (+) and Mode II (-)	Expansion of Disciplinary Programs without or with Marginal Linkages to Mode-II Programs only	Mode II-Programs Confined to Relatively Small Niches only, Weak or No Linkages to Mode I-Programs

Co-Evolutionary Patterns of Type IV:

	Disciplinary Programs	Transdisciplinary Programs
Type of Development	Relative Decline in Disciplinary Program Production	Relative Decline of Transdisciplinary Programs
Empirical Instances: "Negative Interaction" between Mode I (-) and Mode II (-)	Below Average Growth of Disciplinary Programs (Weak Ties to Mode II-Segments)	Below Average Growth of Mode II-Programs (Weak Ties to Mode I-Segments)

Table 14: Potential Sustainability and Co-Evolutionary U-Turns in Modern Societies (Code and Network Levels)

Co-Evolutionary Self-Reinforcing Movements of Type I:

	Network Formations	Program Formations
Type of Development	Strong Expansion of Actor Networks	Strong Expansion in the Knowledge Bases
Historical Instances:	Science-Based Catching Up-Processes	New Science and Technology Programs, Opening up New Niches For Input/Within-put/Output Innovations

Co-Evolutionary U-turns of Type II:

	Network Formations	Program Formations
Type of Development	Lagging Behind in Market/ Protective Belt Networks	High Status in Knowledge Production
Historical Instances:	Network Distribution Failures	Core Knowledge Bases of Science and Technology Programs (United Kingdom 1945-2000)

Co-Evolutionary U-turns of Type III:

	Network Formations	Program Formations
Type of Development	Strong Advances in Market/ Protective Belt Networks	"Lagging Behind" in the Knowledge Bases
Historical Instances:	"Imitation-Based" Catching-Up-Processes (Austria 1945–2000)	Peripheral Knowledge Bases Only

Co-Evolutionary Patterns of Type IV:

	Network Formations	Program Formations
Type of Development	Relative Decline in Market/ Protective Belt Networks	Relative Decline in Knowledge Bases
Historical Instances:	Main Development Patterns for Peripheral Regions	Main Developmental Patterns for Peripheral Knowledge Bases

4.4. THE SPATIAL DIMENSIONS OF CO-EVOLUTIONARY DEVELOPMENT PATTERNS: GLOBAL AND REGIONAL DOMINANCE AND SYMMETRY RELATIONS

Concluding the transfer modules on the shape of co-evolutionary macro-trajectories from an epigenetic point of view, an additional hint, once again in a Neo-Polanyian spirit, can be provided on the entangled nature of spatial dimensions and the resulting multiplicity of power structures and relations, generating the potentially sustainable or U-shaped patterns. Restricted to the network levels and to a macro-perspective alone, the power architectures of network formations assume a highly complex character which is due to the variety of spatio-temporal domains.

> First, a homeostatic configuration between market networks and protective networks can be constructed for at least three major spatial macro-domains, namely for the global levels, for national levels and, finally, for sub-national or regional levels. In each of these spatial ensembles, a co-evolutionary interplay between market expansion and protective differentiation can be identified which exhibits an enormous amount of variation as well as of substitution potential.
>
> Second, these different spatial levels are interconnected in an intriguing fashion since market network actors, say at the global levels, are at the same time actors within specific national or regional levels as well. Moreover, these actor network configurations exhibit a rich diversity of vertical linkages in both directions, namely exchanges from above as well as from below. Thus, transfers, exchanges and interlinkages "from above" become a distinctive element of actor network integration across the lower spatial levels which runs counter, among other things, to simple "aggregative" visions with respect to the constitution of society.
>
> Third, any distribution of symmetry/asymmetry relations between these three spatial levels is empirically feasible and reachable. Thus, asymmetry relations at the global levels can be accompanied by symmetrical relations in a number of regional or national levels. Furthermore, the reverse pattern may occur too, where asymmetrical configurations at the national levels are accompanied by a symmetrical global configuration of global market players and global protective belt ensembles. Finally, substitution processes at local or regional levels within markets or protective belts, even if successful, cannot substitute missing arrangements at the global level – and vice versa.
>
> Fourth, the entangled and intricate actor network formations are characterized by a huge potential for traps, paradoxes and fallacies. Thus, operations by the protective belt at the national level may exert drastic consequences at the global level or vice versa. High tariff walls and "beggar thy neighbor policies", enacted by nations around

the world during the "Great Depression",[30] led to a reduction in the volume of global trade from 3000 Mill. US$ in 1929 to 944 Mill. US$ in February 1933.

One of the upshots of these quite general considerations lies in the emphasis on the importance of the global and long-term dimensions of the actor-network formations and their impact for lower spatio-temporal strata. Table 15 provides a very raw sketch on a global phase transition from a more or less symmetrical pattern to a by and large asymmetrical configuration within the last fifty years. A few points in Table 15 should be given special emphasis:

First, the most dramatic changes between the two stages lies, on the one hand, in the emergence of strong global actors in the market sphere without corresponding counterparts in the networks of the protective belt. Thus, a symmetrical pattern of comparatively weak global network actors during the 1950's or 1960's and of a weak global protective belt has been transformed into an asymmetrical ensemble with a strong market lead, headed, not surprisingly, by financial markets and a whole array of new financial products, and lagging protective formations.,

Second, the essential coordination/regulation/repair function of the protective belt at the global level cannot be maintained under these asymmetric circumstances. Thus, new regulations for the world system on trade or investment (WTO, MAI, etc.) clearly reflect an asymmetrical ensemble which leaves little or no room both for new global actors within the protective belt or for national or regional efforts for new coordination/ control/ regulation/ repair instruments.

Third, these asymmetric patterns at the global levels create a new set of problems for the national or regional levels as well which, moreover, cannot be accomodated within the national or regional coordination/regulation/repair capacities. It can be safely argued that the recent discussion on financing the welfare state reflects, above all, the decreasing financial interconnections between market networks and protective belt – and the saturation limits, reached through an expansion of taxations on labor and on mass consumption.

Fourth, despite a gradual "awakening" of global actors at the level of NGO's, the most essential counter-movement within the global protective belt should be seen in the reconfiguration of new very large-scale spatial units, comprising sets of well-established national systems as a whole. With the *expansion* of the European Union as most prominent example, new actor networks within the protective belt come into play with a comparatively high coordination/regulation/repair capacity. Moreover,

---

[30] To give some numerical examples: With 1913=100, tariffs are raised in Germany in 1931 to 231, in France to 160, Italy 195, Switzerland 245, Spain 185. (Müller, 1988:352)

these new network actors for the protective belt are in the process of establishing the necessary feedback linkages for democratic legitimization, adding. Likewise, similar large-scale integrations of national systems can and will be observed in Latin America or Asia, while global actors like the United Nations will experience, in all probability, another period of relative decline or stagnation.

In this manner, the Neo-Polanyian journey through a variety of different types of societal co-evolutionary movements has come to an end.

5. A TRANSFER MODULE FOR THE MULTIPLICITY OF MACRO-SOCIETAL ENSEMBLES: THE NOTION OF "EPISTEMIC PERSPECTIVES"

So far, the notion of societal macro-ensembles and their building blocks has been employed very frequently throughout the transfer modules. In a final move, the epigenetic transfer modules for the analysis of macro-societal evolution will be enlarged with a final group of typologies, pointing in accordance with the theoretical core-assumption on the multiplicity of the "units of evolution" on the multiplicity and variety of societal building blocks. Here, one is led to a rich and irreducible manifold of macro-societal ensembles as well as to a comparatively large number of different and, above all, irreducible epistemic perspectives or, to borrow Jürgen Habermas´ term, "erkenntnisleitende Interessen" (Habermas, 1968).

In a first part, the concept of "epistemic perspectives" will be introduced in a slightly formal manner. The starting point lies in a well-known configuration which has been emphasized, above all, by Niklas Luhmann (1984, 1997) or by the recent constructivist movement, namely the practically infinite description potential for an infinitely complex environment, societal and otherwise, and the resulting necessities for selection procedures. One of the interesting upshots of the human descriptive condition lies in the summary, presented in Table 21, which gives a preliminary and by no means complete overview of the contemporary range of macro-societal approaches.

The empirical multiplicity of approaches for macro-societal analyses, exhibited in Table 16, will lead to the concept of "epistemic perspectives" since these different macro-societal traditions differ with respect to five essential points.

Table 15: Co-Evolution at the Global Levels of the Modern World System $\{TM_{IVd}\}$

Symmetrical Patterns:
The Co-Evolution between Market Networks and Protective Belts at the Global Levels (1945-1973)

	Market Networks	Protective Belt
Main Network Actors	Multinational Enterprises	International Organisations (IMF, World Bank) New International Assemblies (European Economic Union)
Main Domains	Strong Expansion of Medium and High Tech Industrial and Service Sectors at the Global Levels (with Weak Global Network Actors)	Weak Development of Supervision Super-Structure at the Global Levels
Self-Organizing Stabilization and Coordination Systems at the Global Level	Dirty Floating; Global Trade, "Lender of Last Resort" (USA)	Institutional Support for Self-Organizing Global Market Networks (GATT, Uruguay-Round, etc.)

Symmetrical Patterns:
The Co-Evolution between Market Networks and Protective Belt at the National Levels 1945-1973 (Advanced Regions)

	Market Networks	Protective Belt
Main Actors	Multinational and National Firms	State-Networks, Associations etc.
Core Domains	Leading Industrial Sectors (Automobiles, Air-Carriers, etc.)	"Welfare State-" Networks
Self-Organizing Stabilization and Coordination Systems	International Trade, Linking National Currencies to the Dollar, etc.	Corporatist Arrangements; Welfare-State-Market Interlinkages

Table 15: Co-Evolution at the Global Levels of the Modern World System (Continued)

Asymmetrical Patterns:
The Co-Evolution between Market Networks and Protective Belts at the Global Levels (1973-???)

	Market Networks	Protective Belt
Main Asymmetric Network Actors	Transnational Enterprises	International and Transnational Organisations; New Supra-National Assemblies (European Union)
Main Domains	Strong Expansion of Leading Sectors in Services (incl. Finance) and Information Infrastructure	Weak Development Supervision Super-Structure at the Global Levels; Gradual Emergence of New Protective Regulations and Supervision within Large Spatial Domains (like the European Union)
Self-Organizing Stabilization and Coordination Systems at the Global Level	Off-shore Banking; Global Trade, Global Financial Floatings; Currency Blocks (Dollar, EURO, YEN) etc.	Institutional Support for Self-Organizing Global Market Networks (WTO, MAI, etc.); Declining Capacities for the Old Organizational Settings (IMF, World Bank)

Asymmetrical Patterns:
The Co-Evolution between Market Networks and Protective Belt at the National Levels 1973–??? (Advanced Regions)

	Market Networks	Protective Belt
Main Actors (National, International)	Transnational and National Enterprises	State-Networks, Self Organizing Networks, Associations ...
Main Domains	Leading Service-Information Sectors in Powerful Expansion	"Welfare State-Arrangements", in Relative Decline
Self-Organizing Stabilization and Coordination Systems at the Global Levels	International Trade Linking National Currencies to Currency Blocks etc.	Corporatist Arrangements in Relative Decline (esp. Unions) Intensification of local or national self-organizing networks ("communitarian response")

First, any of the major epistemic perspectives in Table 16 is characterized by a different theoretical core and, thus, by a set of specific basic concepts and relations. A gender focus will utilize a distinctly different set of basic concepts than, say, a cultural and or religious life world focus. Consequently, the basic relations between the theoretical core should be viewed as both independent, irreducible or non-deductive.

Second, each of these traditions is characterized by a different set of paradigmatic examples in which they demonstrate their basic descriptive or explanatory power. Thus, Ulrich Beck´s "Risk Society", Francis Fukuyama´s "The End of History" and Samuel P. Huntington´s "Clash of Civilizations" may be viewed as interesting cases, stressing high technology risks and environmental hazards like Three Mile Island or Tschernobyl (Ulrich Beck), innovation and democratization processes (Fukuyama) or religious and world view conglomerates and their borders as well as their intersections (Samuel P. Huntington).

Third, despite a special focus and a small number of specialized paradigmatic examples, each of these epistemic macro-perspectives is able to integrate and incorporate the processes and structures of other macro-traditions. Thus, modernization theory II can be utilized for an analysis of gender relations, learning and adaptation structures or the status of the environment. Likewise, a risk focus can be used for innovation processes, cognitive structures or gender relations, etc.

Fourth, by fulfilling the first two conditions, each of these epistemic perspectives makes an explicit or, more importantly, an implicit distinction between core-theoretical domains and peripheral ones. Thus, an innovation perspective implies a core set of innovation and diffusion concepts and moving other conceptual domains into a closer or wider periphery.

Fifth, the basic relations between these epistemic perspectives is neither one of deduction or induction nor of complementarity. These different perspectives do not add up to a well-defined whole, representing a societal totality. On the contrary, the overall relations between various epistemic perspectives should be seen thus, in a constructivist fashion, as mutually irreducible and, in most instances, as particularly well suited for special investigative purposes.

Sixth, epistemic perspectives constitute, as a guiding metaphor, a special focus for the socio-economic universes by reconfiguring the socio-economic universes around these different foci. Rather then the "puzzle metaphor" which adds different perspectives into a consistent and well-suited totally, the metaphor of a kaleidoscope seems more appropriate where a set of building blocks organizes itself into a specific configuration and exhibits a special pattern. Additionally, a particular movement of such a kaleidoscope creates the kaleiodoscopic pattern in question.

Table 16: Main Epistemic Perspectives for Macro-Societal Analyses {TM_{Va}}

MAIN FOCUS	LEADING METAPHORS	THEORIES
Attractor/Equilibrium-Focus:	"Modernization"	Theories of Classical Modernization, of Modernization II, etc.
Cognitive Focus:	"Knowledge Society"	Theories of Knowledge Societies, Theories of Learning Organizations or Societies, etc.
Communication/Linguistic Focus:	"Information Society"	Code-based Postmodernism, etc.
Cultural/Life-World/ Religious Focus:	"Civilizations"	"Clash of Civilizations", "Trust", "Life-Styles", "Sibling Society", etc.
Demographic Focus:	"Aging Societies"	Theories of Demographic Transitions, of Life-Courses, etc.
Economic Focus:	"Globalization"	Theories of Transnational Enterprises, of Transnational Relations, "World Systems Analysis, etc.
Environmental Focus	"Sustainable Societies"	Theories of Sustainability, of Environmental Exchanges, etc.
Exchange Focus:	"Media Societies"	Media-Based Postmodernism, etc.
Functional Focus:	"Differentiated So-" cieties"	Neofunctionalism, etc.
Gender Focus:	"Patriarchic Societies"	Theories of Exclusion, of Power, of Gender Relations, etc.
Innovation/Change-Focus:	"National Innovation Systems"	Theories of National Innovation Systems, etc.
Risk-Focus	"Risk-Societies"	Risk-versions of Post-Modernism or of New Forms of Modernization, etc.
Social Structure Focus:	"Class Societies"	Theories of Classes, of Stratification, of "Habitus-Formations", etc.

Seventh, the choice of a particular perspective is dependent on the core question and problems under investigation. Thus, problems of socio-technological development are best investigated under an innovation perspective while for problem domains like poverty and exclusion, new approaches within the gender or the social structure perspective will be of best use.

6. A TRANSFER MODULE FOR THE MULTIPLICITY OF SPATIAL MACRO-SOCIETAL ENSEMBLES WITHIN A SINGLE EPISTEMIC PERSPECTIVE: THE FOCUS ON INNOVATIONS

As a final application domain, the ERP-framework can be enlarged with another "transfer module" for the study of spatially differentiated societal actor networks which stand under a general innovation perspective and can be qualified, thus, as spatial innovation systems. Moreover, this particular transfer module yields a high "cash value" (Wilfried Sellars) with respect to the solution of a notorious problem within the recent innovation literature, namely with respect to the "boundaries" associated with "National or Regional Innovation Systems". In conventional accounts of National Innovation Systems, one is confronted with definitions relying on "networks of institutions" (Freeman, 1987) or on interaction relationships "in the production, diffusion and use of new and economically useful knowledge" (Lundvall, 1992: 2). Consequently, the resulting "boundary problem" asks for suitable borders and demarcations for "institutional networks" or "interaction relationships".

Within the ERP-framework, urban, regional, national or global innovation systems are to be understood, first, as different types or families of dual-level ensembles with a self-similar composition at the urban, regional, national, or global levels and, second, as a special epistemic perspective, stressing, above all,

a multiplicity of "program pools" and a multiplicity of actor network arrangements, interlinked via multiple "embeddedness relations" ...

different types of systemic generality (single ensembles, dual ensembles, triple ensembles, n-ary ensembles, societal ensembles ...)

different building blocks for *each* of the code levels ...

different building blocks for *each* of the network levels on the micro-levels (networks of individuals, groups, small departments, individual firms, single institutes ...), on the meso-levels (networks of organizations (firms, institutes, ...) and on the macro-levels (networks of economic sectors, clusters, professions, scientific disciplines ...)

a *universal* mode of recombinations, i. e. of inventions, via "recombination operators", applicable *both* to the code *and* to the network levels ...

a *universal* mode of innovation diffusion via "complex diffusion models with integrated evaluation measures", applicable *both* to the code *and* to the network levels ...

different landscapes of *comparative advantages*, depending on the choices of building blocks *and* on the main focus of analysis (code-oriented, network-centered or focused on code-network interactions) ...

different patterns of production, interaction and diffusion of code system-innovations (new programs) and actor network-innovations (new inputs, new input⇔withinput⇔ output structures), *again* depending on the selections of building blocks .

Consequently, the present chapter will bring in a highly condensed form an overview of an epigenetic phenomenology of spatially distributed innovation systems (SIS) which culminates in Table 17 with distinctions of various groups of UIS (Urban Innovation Systems), RIS (Regional Innovation Systems), NIS (National Innovation Systems) and GIS (Global Innovation Systems)

Table 17: Types of Spatial Innovation Systems (SIS) {TM_{VIa}}

	Dimension I: Systemic Generality				
	Single	Dual	Triple	N-ary	Societal
Dimension II: Spatial Generality					
Urban	UIS I	UIS II	UIS III	UIS N	UIS S
Regional	RIS I	RIS II	RIS III	RIS N	RIS S
National	NIS I	NIS II	NIS III	NIS N	NIS S
Global	GIS I	GIS II	GIS III	GIS N	GIS S

From Table 17, three important SIS families will be discussed, namely a single SIS I configuration, N-ary SIS ensembles and, finally, SIS S arrangements. In doing so, it is hoped to distinguish between a large number of possible demarcations and boundaries and to arrive at a more transparent way of identifying special classes of SIS ensembles.

6.1. SINGLE MACRO-ENSEMBLES WITHIN AN INNOVATION PERSPECTIVE

Taking the science system as a reference case of a SIS-I unit, the following points become of major epigenetic importance.

The program pool for SIS I consists of all those (re)productive programs, including neural ones, which are an integral part of the C $\Rightarrow$ N or the C $\Leftrightarrow$ N type of embeddedness-relations. Thus, for the scientific system, the internally generated output as well as programs from other spheres with *indispensable* roles in the (re)production of the science system, become integral components of the scientific program pool. To point to somewhat unusual domains, organization schemes, developed within pre-modern crafts and guilds, monasteries or modern state bureaucracies have become part and parcel of the program pool of the science system, too. Architectonic code systems for buildings are used in the construction of universities and research institutes. Symbolic or graphical codes, used and propagated in life-world domains like education or "visual information systems", are gaining rapid ground as a way for transporting scientific messages as well. New multimedia genres enter as an important means of communicating and diffusing new scientific results. Thus, the program pools for a SIS I ensemble becomes a *mixture* between program-components from *various* societal systems.

Second, the network-levels for a SIS I configuration consist, by and large, of a collection of *specific* network formations, depending on the choices of particular building blocks. Again referring to the scientific system, the building blocks for actor networks can be constructed from individual scientists, scientific schools, research units, scientific disciplines and sub-sub-disciplines, specific scientific production types which characterize the output of actor networks, etc. At this point, it must be sufficient to point to an *irreducible multiplicity* of different arrangements of building blocks$_N$ which, in turn, require selection procedures for a specific choice of basic elements.

Third, both the *internal* and the *external* structures for code-level and network-level processes comprise a large number of different exchange media, ranging from specialized languages, higher level "themas", "chunks" (Douglas R. Hofstadter) or, alternatively, "metaphors" (Sabine Maasen, Peter Weingart) to financial flows, etc.

The *specific* choices of boundaries, components and exchange relations determine, in effect, the landscapes of comparative advantages, the innovation character of new network features, etc. Thus, the highly abstract specification requirements for SIS I ensembles *have* to leave open most of the *actual* specification work. Nevertheless, a special "transfer module" has been constructed which characterizes a family of different innovation systems at various spatial aggregation levels.

6.2. N-ARY MACRO-ENSEMBLES WITHIN AN INNOVATION PERSPECTIVE

Turning now to a SIS N arrangement (N = 2, 3, 4 ...), the SIS program pools as well as actor network ensembles exhibit, by necessity, a *significantly* enhanced configuration.

> The program pools for SIS N comprise, quite naturally, all those (re)productive programs which follow the vertical epigenetic embeddedness-relations. Thus, internally generated programs as well as programs from other spheres with *indispensable* roles in the (re)production of the n-ary system, become necessary components of the program pools. Following especially Luhmann (1984, 1997), it is surprising to note the redundancies in the program pools across different social systems since individual or organizational knowledge bases in different domains like in the economic system as well as in the scientific or in the cultural domain are nevertheless characterized, *inter alia*, by the replication of a large amount of identical program elements. Thus, while the program pools for a SIS N ensemble *must* be a mixture between program components from *various* societal systems, the sheer amount of redundancies and replications across systemic fields remains a highly interesting and relevant feature.
>
> *Second*, the network levels for a SIS N configuration consist, by and large, of ensembles of interlinked actor networks whose specification depends, however, crucially on the choices of the *specific* building blocks for the N systems under investigation. At this point, it must be sufficient to point to a simple "law of increasing diversity", since a large number of different specification choices across systems leads to a *rapid* increase in subsequent SIS N ensembles or, somewhat misleading, to divergent socio-ecconomic ecologies.
>
> *Third*, the *internal* structures, restrictions and flows between code level- and network level-processes have to include both an *intra*systemic as well as an *inter*systemic part. Once again, the "law of increasing diversity" operates on these *internal* exchanges as well, since large numbers of potentially relevant intra- and intersystemic exchanges become available, in principle.
>
> *Fourth*, the *external* relations and exchanges of SIS N are, once again, dependent on the particular building block-specifications, leading from specific cognitive code-systems and their *cognitive* environments to eco-systems and their corresponding environments or to global systems-environment networks with *dense* linkage structures both at the code as well as on the network levels.

With these qualifications, interwoven and entangled ensembles like the so-called national "triple helices" (economy, science, state) or even more complex compounds can be built up as appropriate epigenetic units.

6.3. SOCIETAL MACRO-ENSEMBLES WITHIN AN INNOVATION PERSPECTIVE

Under the heading of a societal SIS S, the following set of *additional* minimal requirements can be laid out. Here, the additional step consists in more precise and empirically accessible definitions of the scope and the extension of the term "societal" which turn out to be far from trivial or self-evident. Two essential requirements, one called "totality condition", the other one a "spatio-temporal completeness-condition" will be postulated which a *societal* SIS-ensemble, in contrast to a SIS N configuration, must meet simultaneously.

> A *societal SIS S complex* must fulfill, first, the "totality requirement" and must, thus, be composed in a way to include *core (re)production* processes in market networks and in the networks of the protective belt, including its household and its civil society components or its network formations for the scientific-technological sphere or for the cultural and artistic domains.
>
> *Second*, a societal ensemble must meet the demand for "spatio-temporal completeness", that is, the requirement to account for a complete "accounting" of "routines" and "operations" of the building blocks selected for the various actor network formations. Thus, *societal* configurations, taking *individuals* as their basic element, must be defined in a way so that "action-sequences" or "routines" of individuals at the working place, in households, in public places etc., can be completely *integrated,* in principle, into the societal specifications.

Consequently, a *societal* SIS configuration must be able to account for innovation and diffusion processes in the core areas of contemporary knowledge societies in an *inclusive* manner. Aside from these two basic requirements, the specification of a SIS S complex follows the same guidelines which have been laid out in the course of SIS N configurations.

After the description of different SIS families, a short set of additional definitions will offer a more refined partitioning or clustering of innovation systems by integrating the time-dimension into the format of Table 17. More concretely, the following temporal specifications can be offered:

> With respect to *time periods,* SIS ensembles can be separated in short-term, medium-term and long-term configurations, enlarging, thus, the number of ensembles in Table 17 from 20 to 60. Consequently, urban, regional, national or international innovation systems of the type II or III can be studied with respect to

their short-term evolution (changes between one and five years), their medium-term paths (five to twenty five years) or in their long-term trajectories (more than twenty-five years)

In this manner, an important "transfer module" for the analysis of spatially distributed macro-ensembles within an overall innovation perspective has been established which differentiates via spatio-temporal as well as systemic scales and offers, thus, a "satisfying" solution to the boundary problems, inherent in the specification of innovation systems, global, national, regional or otherwise.

7. THE EPIGENETIC RESEARCH PROGRAM: FUTURE MACRO-SOCIETAL PERSPECTIVES

With this set of transfer modules, a preliminary overview on epigenetic research at the macro-societal levels has been completed. With the focus on "embedded knowledge cycles", "double-movements" and "U-turns", a new set of tools and instruments has been constructed which should prove its usefulness for the long-term "knowledge based" development over the last centuries — and, due to its reliance on evolutionary stable classifications and schemes, for the decades ahead as well ....

BIBLIOGRAPHY

AINSLIE, G. (1992), *Picoeconomics. The Strategic Interaction of Successive Motivational States within the Person*. Cambridge:Cambridge University Press.
ALEXANDER, J. C. et al. (1987)(eds.), *The Micro-Macro Link*. Berkeley:University of California Press.
ALEXANDER, J. (1994), "Modern, Anti, Post, and Neo: How Social Theories Have Tried to Understand the 'New World' of 'Our Time'", in: *Zeitschrift für Soziologie* 3, 165 - 197.
ALEXANDER, J.C. (1995), *Fin de Siècle Social Theory. Relativism, Reduction, and the Problem of Reason*. London:Verso.
ALEXANDER, R.D. (1977), "Natural Selection and the Analysis of Human Sociality." Pp. 283-337 *in Changing Scenes in Natural Sciences,* edited by C. E. Goulden. Philadelphia, PA:Philadelphia Academy of Natural Sciences.
ANDERSON, P.W., K.J. ARROW, D. PINES (1988)(eds.), *The Economy as an Evolving Complex System. The Procewedings of the Evolutionary Paths of the Global Economy Workshop, Held September, 1987 in Santa Fe, New Mexico*. Redwood City:Addison-Wesley.
ARROW, K.J., S. HONKAPOHJA (1985)(eds.), *Frontiers of Economics*. Oxford:Basil Blackwell.
ARROWSMITH, D.K., C.M. PLACE (1994), *Dynamische Systeme. Mathematische Grundlagen*. Heidelberg:Spektrum Akademischer Verlag.
ARTHUR, W.B. (1989), *The Economy and Complexity*, in: D.L. STEIN (1989), 713 - 740.
ASHBY, R. (1974), *Einführung in die Kybernetik*. Frankfurt:Suhrkamp.
ASHBY, R. (1981), *Mechanisms of Intelligence: Ross Ashby's Writings on Cybernetics*, ed. by R. Conant. Seaside:Intersystems Publications.
AVENI, A.F. (1989), *Empires of Time. Calendars, Clocks and Cultures*. New York:Basic Books.
AYRES, R.U., U.E. SIMONIS (1994)(eds.*), Industrial Metabolism: Restructuring for Sustainable Development*. Tokyo:United Nations University Press.
BAILEY, K.D. (1990), *Social Entropy Theory*. Albany:State University of New York Press.
BAK, P. (1996), *How Nature Works. The Science of Self-Organized Criticality*. New York:Springer-Verlag.
BALZER W., C.U. MOULINES, J.D. SNEED (1987), *An Architectonic for Science. The Structuralist Program*. Dordrecht:Reidel.
BALZER W., D.A. PEARCE, H.J. SCHMIDT (1984*), Reduction in Science. Structure, Examples, Philosophical Problems*. Dordrecht:Reidel.
BARKOW, J.H., L. COSMIDES, J. TOOBY (1992)(eds.), *The Adapted Mind. Evolutionary Psychology and the Generation of Culture*. Oxford:Oxford University Press.
BARLOW, C. (³1993)(ed.), *From Gaia to Selfish Genes. Selected Writings in the Life Sciences*. Cambridge:The MIT Press.
BARNSLEY, M. (1988), *Fractals Everywhere*. Boston:Academic Press.
BARRETT, E. (1989)(ed.), *The Society of Text. Hypertext, Hypermedia, and the Social, Construction of Information*. Cambridge:The MIT Press.
BARROW, J.D. (1996), *Die Natur der Natur. Wissen an den Grenzen von Raum und Zeit*. Reinbek bei Hamburg:Rowohlt.
BARTON, G.E., R.C. BERWICK, E.S. RISTAD (1987), *Computational Complexity and Natural Language*. Cambridge:The MIT Press.
BASIEUX, P. (1995), *Die Welt als Roulette. Denken in Erwartungen*. Reinbek bei Hamburg:Rowohlt.
BATTEN, D., J.L. CASTI, B. JOHANSSON (1987)(eds.), *Economic Evolution and Structural Adjustment*. Berlin:Springer.
BECK, U. (1986), *Risikogesellschaft. Auf dem Weg in eine andere Moderne*. Frankfurt:Sihrkamp.
BEENSTOCK, M. (²1984), *The World Economy in Transition*. London:George Allen&Unwin.
BEER, S. (1994a), *Decision and Control. The Meaning of Operational Research and Management Cybernetics*. Chichester:John Wiley&Sons.
BELL, D. (1979a), *Die nachindustrielle Gesellschaft*. Reinbek:Rowohlt.
BELL, D. (1979b), *Die Zukunft der westlichen Welt. Kultur und Technologie im Widerstreit*. Frankfurt:Fischer.
BENDALL, D.S. (1983)(ed.), *Evolution from Molecules to Men*. Cambridge:Cambridge University Press.
BENIGER, J.R (1986), *The Control Revolution. Technological and Economic Origins of the Information Society*. Cambrisge:The MIT Press.
BERGER, J. (1986)(Ed.), *Die Moderne - Kontinuitäten und Zäsuren. Soziale Welt, Sonderband 4*. Göttingen.
BERLINSKI, D. (1986), *Black Mischief. The Mechanics of Modern Science*. New York:William Morrow and Company.
BERTALANFFY, L. (1968), *General System Theory. Foundations, Development, Applications*. New York:Harper&Row.
BIJKER, W.E., J. LAW (1992)(eds.), *Shaping Technology/Building Society. Studies in Sociotechnical Change*. Cambridge:The MIT Press.
BILGRAMI, A. (1994), *Belief and Meaning. The Unity and Locality of Mental Content*. Cambridge:Basil Blackwell.
BINGHAM, J.E., G.W.P. DAVIES (²1978), *A Handbook of Systems Analysis*. London:Mc Millan.
BIRKE, L., R. HUBBARD (1995), *Reinventing Biology. Respect for Life and the Creation of Knowledge*. Bloomington:Indiana University Press.
BODEN, M.A. (1990), *The Creative Mind. Myths and Mechanisms*. London:Cardinal.
BOUDON, R. (1980), *Die Logik gesellschaftlichen Handelns. Eine Einführung in die soziologische Denk- und Arbeitsweise*. Neuwied:Luchterhand.
BOULDING, K. (1981), *Ecodynamics. A New Theory of Societal Evolution*. Beverly Hills-London.
BOURDIEU, P. (1982), *Die feinen Unterschiede. Kritik der gesellschaftlichen Urteilskraft*. Frankfurt:Suhrkamp.
BOURDIEU, P. (1991), *Language and Symbolic Power*. Cambridge:Cambridge University Press.
BOYD, R., P.J. RICHERSON (1985), *Culture and the Evolutionary Process*. Chicago:The University of Chicago Press.

BRAUDEL, FERNAND (1982), *Civilization and Capitalism 15th - 18th Century*, Vol. 2 *The Wheels of Commerce*. New York: Harper&Row.

BRAUDEL, F. (1986), *Civilization and Capitalism 15th - 18th Century*, Vol. 3 *The Perspective of the World*. New York: Harper&Row.

BROCKMAN, J. (1995), *The Third Culture. Beyond the Scientific Revolution*. New York:Simon&Schuster.

BROOKS, D.R., E.O. Wiley (²1988), *Evolution as Entropy. Toward a Unified Theory of Biology*. The University of Chicago Press.

BUCHANAN, J.M. (1986), *Liberty, Market and the State. Political Economy in the 1980s*. Brighton:Harvester Press.

BÜHL, W.L.(1995), *Wissenschaft und Technologie. An der Schwelle zur Informationsgesellschaft*. Göttingen:Verlag Otto Schwartz&Co.

BUND, MISEREOR (1996)(eds.), *Zukunftsfähiges Deutschland. Ein Beitrag zu einer global nachhaltigen Entwicklung*. Basel:Birkhäuser Verlag.

BUNGE, M. (1977), *Treatise on Basic Philosophy. Ontology I: The Furniture of the World*. Dordrecht:Reidel.

BUNGE, M. (1979), *Treatise on Basic Philosophy. Ontology II: A World of Systems*. Dordrecht:Reidel.

BUNGE, M. (1983a), *Treatise on Basic Philosophy. Epistemology and Methodology I: Exploring the World*. Dordrecht:Reidel.

BUNGE, M. (1983b), *Treatise on Basic Philosophy. Epistemology and Methodology II: Understanding the World*. Dordrecht:Reidel.

CALLON, M. et al. (1988), *Mapping the Dynamics of Science and Technology*. Cambridge:MIT Press.

CALVIN W.H. (1990), *The Cerebral Symphony. Seashore Reflections on the Structure of Consciousness*. New York:Bantam Books.

CALVIN, W.H., G.A. OJEMANN (1995), *Einsicht ins Gehirn. Wie Denken und Sprache entstehen*. München:Carl Hanser Verlag.

CAMPBELL, J. (1984), *Grammatical Man. Information, Entropy, Language, and Life*. Harmondsworth:Penguin.

CARVALLO ; M.E. (1988)(ed.), *Nature, Cognition and System I. Current Systems-Scientific Research on Natural and Cognitive Systems*. Dordrecht:Reidel.

CASDAGLI, M., S. EUBANK (1992)(eds.), *Nonlinear Modeling and Forecasting*. Redwood City:Addison-Wesley.

CASTI J.L., A. KARLQVIST (1989)(eds.), *From Newton to Aristotle*. New York:Basic Books.

CASTI, J.L. (1989), *Alternate Realities. Mathematical Models of Nature and Man*. New York et al.

CASTI, J.L. (1992), *Reality Rules*, 2 Bde. New York et al.

CASTI, J.L. (1994), *Complexification. Explaining a Paradoxical World through the Science of Surprise*. New York:Harper Collins Publishers.

CASTI, J.L. (1996), *Five Golden Rules. Great Theories of 20th Century Mathematics - and Why They Matter*. New York:John Wiley&Sons.

CAUDILL, M. (1992), *In Our Own Image. Building an Artificial Person*. New York:Oxford University Press.

CAVALLI-SFORZA, L. L., M. W. FELDMAN (1981), *CulturalTransmission and Evolution*. Princeton:Princeton University Press.

CHENEY, D.L., R.M. SEYFARTH (1990), *How Monkeys See the World. Inside the Mind of Another Species*. Chicago:University of Chicago Press.

CHOMSKY, N. (1995), *The Minimalist Program*. Cambridge:The MIT Press.

CHURCHLAND, P.M. (1995), *The Engine of Reason, the Seat of the Soul. A Philosophical Journey into the Brain*. Cambridge:The MIT Press.

CLEEREMANS, A. (1993), *Mechanisms of Implicit Learning. Connectionist Models of Sequence Processing*. Cambridge:The MIT Press.

COHEN, J., I. STEWART (1994), *Chaos-Anti-Chaos. Ein Ausblick auf die Wissenschaft des 21. Jahrhunderts*. Berlin:Byblos-Verlag.

COLE, S. (²1995), *Making Science. Between Nature and Society*. Cambridge:Harvard University Press.

COLEMAN, J.S. (1987), "Microfoundations and Macrosocial Behaviour", in: J.C. ALEXANDER et al., op. cit., 153 - 173.

COLEMAN, J.S. (1990), *Foundations of Social Theory*. Cambridge:Harvard University Press.

COLLINS, H.M. (1990), *Artificial Experts. Social Knowledge and Intelligent Machines*. Cambridge:The MIT Press.

COLLINS, H.M. T. Pinch (1993), *The Golem. What Everyone Should Know about Science*. Cambridge:Cambridge University Press.

COVENEY, P., R. HIGHFIELD (1995), *Frontiers of Complexity. The Search for Order in a Chaotic World*. New York:Fawcett Columbine.

CRAMER, F. (³1989), *Chaos und Ordnung. Die komplexe Struktur des Lebendigen*. Stuttgart:DVA.

CUHLS, K., T. KUWAHARA (1994), *Outlook for Japanese and German Future Technology*. Heidelberg:Physica-Verlag.

CUMMINS, R. (1985), *The Nature of Psychological Explanation*. Cambridge:The MIT Press.

DAMASIO, R.A. (1994), *Descartes'Error. Emotion, Reason and the Human Brain*. New York:Grosset/Putnam Book.

DAVID, P.A., D. FORAY, OECD (1994), *Accessing and Expanding the Science and Technology Knowledge Base*. (DSTI/STP/TIP(94)4) Paris:OECD.

DAVIES, M., T. STONE (1995)(eds.), *Folk Psychology. The Theory of Mind Debate*. Oxford:Blackwell Publishers.

DAWKINS, R. (1976), *The Selfish Gene*. Oxford:Oxford University Press.

DAWKINS, R. (1982), *The Extended Phenotype*. Oxford:Oxford University Press.

DAWKINS, R. (1986), *The Blind Watchmaker*. Harlow:Longman Scientific&Technical.

DAWKINS, R. (1995), *River out of Eden. A Darwinian View of Life*. London:Weidenfeld&Nicolson.

DAWKINS, R. (1997), *Climbing Mount Improbable*. Harmondsworth:Penguin.

DEACON, T. W. (1997), *The Symbolic Species. The Co-evolution of Language and Brain*. New York:W. W.Norton.

DENNETT (1986a), *Content and Consciousness*. London:Routledge&Kegan Paul.

DENNETT, D.C. (1986b), "Cognitive Wheels: the Frame Problem of AI", in: C. HOOKWAY (1986)(ed.), *Minds, Machines and Evolution. Philosophical Studies*. Cambridge:Cambridge University Press, 129 - 151.

DENNETT, D.C. (1991), *Consciousness Explained*. Boston:Little, Brown and Company.

DENNETT, D.C. (1995), *Darwin's Dangerous Idea. Evolution and the Meanings of Life*. New York:Simon &Schuster.

DENNETT, D.C. (1997), *Kinds of Minds. Towards an Understanding of Consciousness*. London:Phoenix.

DENNETT, D. C. (1987), *The International Stance*. Cambridge:The MIT Press.

DIDEROT, D. (1969), *Enzyklopädie. Philosophische und politische Texte aus der 'Encyclopèdie' sowie Prospekt und Ankündigung der letzten Bände*. München:dtv.

DONOVAN, A.., L. LAUDAN, R. LAUDAN (1988)(eds.), *Scrutinizing Science. Empirical Studies of Scientific Change*. Dordrecht:Kluwer Academic Publishers.
DORAN, J., N.G. GILBERT (1994)(eds.), *Simulating Societies: the Computer Simulation of Social Phenomena*. London:University of London Press.
DOREN, C.v. (1996), *Geschichte des Wissens*. Basel:Birkhäuser Verlag.
DOSI, G. et al (eds.) (1988). *Technical Change and Economic Theory*, London:Pinter.
DOUGLAS, M. (1987), *How Institutions Think*. London:Routledge and Kegan Paul.
DRETSKE, F.I. (1981), *Knowledge and the Flow of Information*. Oxford:Basil Blackwell.
DRUCKER, P.F. (1993), *Die postkapitalistische Gesellschaft*. Düsseldorf:Econ-Verlag.
DUDEN ([4]1982), *Das Fremdwörterbuch*, Duden Vol. 5. Mannheim:Dudenverlag.
DURHAM, W.H. (1991), *Coevolution: Genes, Culture, and Human Diversity*. Stanford:Stanford University Press.
DURKHEIM, E. (1892) [1933], *The Division of Labor in Society*. New York:Macmillan.
ECO, U. (1972), *Einführung in die Semiotik*. München:dtv Verlag.
ECO, U. (1992), *Die Grenzen der Interpretation*. München:Carl Hanser Verlag.
ECO, U. (1993), *Die Suche nach der vollkommenen Sprache*. München:Verlag C.H. Beck.
EDELMAN, G.M. (1987), *Neural Darwinism*. New York:Basic Books.
EDELMAN, G.M. (1990), *The Remembered Present. A Biological Theory of Consciousness*. New York:Basic Books.
EDELMAN, G.M. (1992), *Bright Air, Brilliant Fire. On the Matter of the Mind*. New York:Basic Books.
EIGEN, M. (1987), *Stufen zum Leben. Die frühe Evolution im Visier der Molekularbiologie*. München-Zürich.
EIGEN, M., P. SCHUSTER (1979), *The Hypercycle: A Principle of Natural Self-Organization*. Berlin:Springer.
EISENHARDT, P., D. KURTH, H. STIEHL (1995), *Wie Neues entsteht. Die Wissenschaften des Komplexen und Fraktalen*. Reinbek:Rowohlt.
ELIAS, N. (1988), *Die Gesellschaft der Individuen*. Frankfurt:Suhrkamp.
ELSTER, J. (1986)(ed.), *The Multiple Self*. Cambridge:Cambridge University Press.
ELSTER, J. (1989), *The Cement of Society. A Study of Social Order*. Cambridge:Cambridge University Press.
EMERY, F.E. (1978), *Systems Thinking. Selected Readings*, vol. 1. Harmondsworth:Penguin.
ERESHEFSKY, M. (1992)(ed.), *The Units of Evolution. Essays on the Nature of Species*. Cambridge:The MIT Press.
ETZIONI, A. (1994), *Jenseits des Egoismus-Prinzips. Ein neues Bild von Wirtschaft, Politik und Gesellschaft*. Stuttgart:Schäffer-Poeschel.
ETZIONI, A. (1995), *The Spirit of Community. Rights, Responsibilities and the Communitarian Agenda*. New York:Fontana Press.
FEATHERSTONE, M., S. LASH, R. ROBERTSON (1995)(eds.), *Global Modernities*. London:Sage Publications.
FEIGENBAUM, E.A., J. FELDMAN (1995)(eds.), *Computers and Thought*. Menlo Park:The AAAI Press.
FELDERER, B. (1996), "The Importance of R&D for Future Industries and the Wealth of Nations", in: *IHS Newsletter* 4, 1 - 3.
FELDERER, B., D. CAMPBELL (1994), *Forschungsfinanzierung in Europa. Trends- Modelle, Empfehlungen für Österreich*. Wien:Manz Verlag.
FELDMAN, M. W. (1988), "Evolutionary Theory of Genotypes and Phenotypes: Towards a Mathematical Synthesis," *in Emerging Synthesis and Science*. Redwood City, CA: Addison Wesley.
FELT, U., H. NOWOTNY (1995)(eds.), *Social Studies of Science in an International Perspective*. Vienna:Institute for Theory and Social Studies of Science.
FERRY, L. (1995), *The New Ecological Order*. Chicago:The University of Chicago Press.
FINKE, R.A., T.B. WARD, S. M. SMITH (1992), *Creative Cognition. Theory, Research, and Applications*. Cambndge:The MIT Press.
FLORA, P., A.J. HEIDENHEIMER ([2]1984)(eds.), *The Development of Welfare States in Europe and America*. New Brunswick: Transaction Publishers.
FLUSSER, V. ([2]1989), *Die Schrift. Hat Schreiben Zukunft*. Göttingen:Immatrix Publications.
FOERSTER, H.v. (1957), "Basic Concepts of Homeostatsis", in: *Homeostatic Mechanisms. Brookhaven Symposia in Biology*, No. 10. S. Brookhaven Laboratory:Upton, N.Y., 216 – 242.
FOERSTER, H.v. (1982), *Observing Systems*. Seaside:Intersystems Publications.
FOERSTER, H.v. (1985), *Sicht und Einsicht. Versuche zu einer operativen Erkenntnistheorie*. Braunschweig:Vieweg.
FOERSTER, H.v. (1993), *Wissen und Gewissen. Versuch einer Brücke*. Frankfurt:Suhrkamp.
FOERSTER, H.v. ([2]1995), *Cybernetics of Cybernetics*. Minneapolis:Future Systems.
FOERSTER, H. v. (1997), *Der Anfang von Himmel and Erde hat keinen Namen. Eine Selbsterschaffung in sieben Tagen*. Wien: Döcker-Verlag.
FONTANA, W. L.W. BUSS (1995), *A Methodology for Generating and Modeling Self-Maintaining Systems. A Research Agenda*. Laxenburg:IIASA.
FORESTER, T. (1985)(ed.), *The Information Technology Revolution*. Oxford:Basil Blackwell.
FORREST, S. (1991)(ed.), *Emergent Computation. Self-Organizing, Collective, and Cooperative Phenomena in Natural and Artificial Computing Networks*. Cambridge: The MIT Press.
FOUCAULT, M. ([3]1979), *Überwachen und Strafen. Die Geburt des Gefängnisses*. Frankfurt:Suhrkamp.
FREEMAN, C. (1983)(ed.), *Long Waves in the World Economy*. London:Butterworths.
FREEMAN, C. (1987), *Technology and Economic Performance. Lessons from Japan*. London:Pinter Publishers.
FREEMAN, C., J. CLARK, L. SOETE (1982), *Unemployment and Technical Innovation. A Study of Long Waves and Economic Development*. London:Frances Pinter.
FREEMAN, C., L. SOETE (1994), *Work for All or Mass Unemployment. Computerised Technical Change into the 21st Century*. London: Frances Pinter.
FREEMAN, J.A. (1991), *Neural Networks. Algorithms, Applications, and Programming Techniques*. Reading et al.
FREESE, L. (1997a), *Evolutionary Connections*. Greenwich:JAI Press.
FREESE, L. (1997b), *Environmental Connections*. Greenwich:JAI Press.
FRITSCH, B. (1974), *Wachstumsbegrenzung als Machtinstrument*. Stuttgart:Deutsche Verlags-Anstalt.
FUKUYAMA (1991), *Trust. The Social Virtues and the Creation of Prosperity*. New York:The Free Press.
GALE, J.S. (1990), *Theoretical Population Genetics*. London:Unwin Hyman.
GALL, J. ([3]1990), *Systemantics. The Underground Text of Systems Lore. How Systems Really Work and Especially How They Fail*. Ann Arbor:The General Systemantics Press.
GARDNER, H. (1985), *The Mind's New Science. A History of the Cognitive Revolution*. New York:Basic Books.
GARDNER, H. (1993), *Creating Minds. An Anatomy of Creativity Seen through the Lives of Freud, Einstein, Picasso, Stravinsky, Eliot, Graham, and Ghandi*. New York:Basic Books.

GAUDIN, T. (1995), *2100. Spiece´s Odyssey.* Montiers:Foundation 2100.
GAZZANIGA, M.S. (1985), *The Social Brain. Discovering the Networks of the Mind.* New York:Basic Books.
GAZZANIGA, M.S. (1995)(ed.), *The Cognitive Neurosciences.* Cambridge:MIT Press
GEERTZ, C. (1983), *Local Knowledge. Further Essays in Interpretative Anthropology.* New York:Basic Books.
GELL-MANN, M. (1994), *Das Quark und der Jaguar. Vom Einfachen zum Komplexen - die Suche nach einer neuen Erklärung der Welt.* München:Piper.
GEORGESCU-ROEGEN, N. (1971), *The Entropy Law and the Economic Process.* Cambridge:Harvard University Press.
GERGEN, K.J. ([2]1994), *Toward Transformation in Social Knowledge.* London:Sage Publications.
GERSHUNY, J. (1983), *Social Innovation and the Division of Labour.* Oxford:Oxford University Press.
GEUS, A.d. (1997), *The Living Company.* Boston:Harvard Business School Press.
GIBBONS, M. et al. (1994), *The New Production of Knowledge. The Dynamics of Science and Research in Contemporary Societies.* London:Sage.
GIBBS, W.W. (1995), "Lost Science in the Third World", in: *Scientific American* 8, 76-83.
GIBSON, K.R., T. INGOLD (1994)(eds.), *Tools, Language and Cognition in Human Evolution.* Cambridge:Cambridge University Press.
GIDDENS, A. (1991), *Modernity and Self-Identity. Self and Society in the Late Modern Age.* Cambridge:Polity Press.
GLANVILLE, R. (1988), *Objekte.* Berlin:Merve-Verlag.
GOEL, V. (1995), *Sketches of Thought.* Cambridge:The MIT Press.
GOLEMAN, D. (1995), *Emotional Intelligence. Why It Can Matter More Than IQ.* New York:Bantam Books.
GOODMAN, N. (1973), *Sprachen der Kunst. Ein Ansatz zu einer Symboltheorie.* Frankfurt am Main:Suhrkamp.
GOODWIN, B. (1995), *How the Leopard Changed Its Spots. The Evolution of Complexity.* New York:Charles Scribner´s Sons.
GOUILLART, F.J., J.N. KELLY (1995), *Business Transformation. Reframing-Restructuring-Revitalizing-Renewing.* Wien:Ueberreuter.
GOULD, S.J. (1989), *Wonderful Life. The Burgess Shale and the Nature of History.* New York:W.W. Norton&Company.
GRANOVETTER, M. (1985), "Economic Action and Social Structure: The Problem of Embeddedness", in: *American Journal of Sociology* 91, 479 - 495.
GREWENDORF, G. (1995), *Sprache als Organ - Sprache als Lebensform.* Frankfurt:Suhrkamp.
GRIFFIN, D.R. (1992), *Animal Minds.* Chicago:The University of Chicago Press.
GRÜTZMANN, K. (1993), *Simulation und Analyse eines dynamischen Entscheidungsmodells mit Gedächtniseffekten*, Diplomarbeit am Institut für Theoretische Physik. Stuttgart:University of Stuttgart.
GRÜTZMANN, K:, G. HAAG (1994), "Gedächtniseffekte und die Entstehung des Neuen", in: *WISDOM* 3/4, 128 - 137.
HAAG, G. (1989), *Dynamic Decision Theory: Applications to Urban and Regional Topics.* Dordrecht:Kluwer.
HAAG, G. et al. (1992)(eds.), *Economic Evolution and Demographic Change. Formal Models in the Social Sciences.* Berlin:Springer.
HAAG, G., K.H. MÜLLER (1992), "Employment and Education as Non-Linear Population Networks I&II", in: G. HAAG et al. (eds.), 349 - 407.
HAARMANN, H. (1990), *Universalgeschichte der Schrift.* Frankfurt:Campus-Verlag.
HABERMAS, J. (1968), *Erkenntnis und Interesse.* Frankfurt:Suhrkamp.
HABERMAS, J. (1981), *Theorie kommunikativen Handelns*, 2 vol. Frankfurt:Suhrkamp.
HAKEN, H. (1977), *Synergetics. An Introduction - Nonequilibrium Phase Transitions and Self-Organization in Physics, Chemistry and Biology.* Berlin: Springer.
HAKEN, H. (1980)(ed.), *Dynamics of Synergetic Systems.* Berlin:Springer.
HAKEN, H. (1982a), *Synergetik. Eine Einführung.* Berlin:Springer.
HAKEN, H. (1982b(ed.), *Evolution of Order and Chaos in Physics, Chemistry, and Biology.* Berlin:Springer.
HAKEN, H. (1983), *Advanced Synergetics. Instability Hierarchies of Self-Organizing Systems and Devices.* Berlin:Springer.
HAKEN, H. (1991), *Synergetic Computers and Cognition. A Top-Down Approach to Neural Nets.* Berlin:Springer.
HANAPPI, G. (1994), *Evolutionary Economics. The Evolutionary Revolution in the Social Sciences.* Aldershot:Avebury.
HAUSEN, K., R. RÜRUP (1975)(eds.), Moderne Technikgeschichte. Köln:Kiepenheuer&Witsch.
HAUSER, M. D. (1997), *The Evolution of Communication.* Cambridge:The MIT Press.
HAYEK, F. v. (1949), *Individualism and Economic Order.* London:Routledge.
HAYEK, F. v. (1967), *Studies in Philosophy, Politics and Economics.* London:Routledge.
HAYKIN, S. (1994), *Neural Networks. A Comprehensive Foundation.* New York:Macmillan College Publishing Company.
HEGEL, G.W.F. (1956), *The Philosophy of History.* New York:Dover Publications.
HEGSELMANN, R., U. MUELLER, K.G. TROITZSCH (1996)(eds.), *Modelling and Simulation in the Social Sciences from the Philosophy of Science point of View.* Dordrecht:Kluwer Academic Publishers.
HEIMS, S.J. (1991), *The Cybernetics Group.* Cambridge:MIT Press.
HELBING, D. (1993), *Stochastische Methoden, nichtlineare Dynamik und quantitative Modelle sozialer Prozesse.* Aachen: Shaker.
HELLER, A. (1995), *Ist die Moderne lebensfähig?* Frankfurt:Campus.
HENNIG, W. (1995), *Genetik.* Berlin:Springer.
HENSEL, M. (1990), *Die Informationsgesellschaft. Neuere Ansätze zur Analyse eines Schlagwortes.* München:Verlag Reinhard Fischer.
HERFEL, W., W. KRAJEWSKI, I. NIINILUOTO, R. WOJCICKI (1995)(eds.), *Theories and Models in Scientific Processes.* Amsterdam:Rodopi.
HIPPEL, E. von (1994), *The Sources of Innovation.* Oxford:Oxford University Press.
HIRSCHMAN, A.O. (1992), *Denken gegen die Zukunft. Die Rhetorik der Reaktion.* München:Carl Hanser Verlag.
HOBSBAWM, E. (1995), *Age of Extremes. The Short Twentieth Century 1914 - 1991.* London:Abacus.
HODGSON, G.M. (1993), *Economics and Evolution: Bringing Life Back to Economics.* Cambridge, UK: Polity Press.
HOFBAUER, J., K. SIGMUND (1984), *Evolutionstheorie und dynamische Systeme. Mathematische Aspekte der Selektion.* Berlin:Paul Parey.
HOFINGER, C., K. GRÜTZMANN (1994), "Das Politik-Modell: Attraktivitäten als Determinanten von Wählerbewegungen in Österreich 1970 - 1990", in: WISDOM 3/4, 79 - 89.

HOFSTADTER, D.R (⁴1982), *Gödel-Escher-Bach. An Eternal Golden Braid.* Harmondsworth:Penguin.
HOFSTADTER, D.R. (1985a), *Metamagical Themas. Questing for the Essence of Mind and Matter.* New York:Basic Books.
HOFSTADTER, D.R. (1985b), *Gödel, Escher, Bach - Ein Endloses Geflochtenes Band.* Stuttgart:Klett-Cotta.
HOFSTADTER, D.R. (1997), *Le Ton beau des Marot. In Praise of the Music of Language.* New York:BasicBooks.
HOFSTADTER, D.R., D.C. DENNETT (1982) (eds.), *The Mind's I. Phantasies and Reflections on Self and Soul.* Harmondsworth:Penguin.
HOFSTADTER, D.R., FLUID ANALOGIES RESEARCH GROUP (1995), *Fluid Concepts and Creative Analogies. Computer Models of the Fundamental Mechanisms of Thought* New York:Basic Books.
HOLLAND, J. (1986), "Escaping Brittleness: The Possibilities of General-Purpose Learning Algorithms Applied to Parallel Rule-Based Systems", in: R.S. Michalski *et al.* (1986)(eds.), *Machine Learning. An Artificial Intelligence Approach*, Vol. II. Los Altos:Morgan Kaufmann Publishers, 593:623.
HOLLAND, J.H. (1988), "The Global Economy as an Adaptive Process", in: P.W. ANDERSON, K.J. ARROW, D. PINES (1988), 117 - 124.
HOLLAND, J.H. (1992), *Adaptation in Natural and Artificial Systems. An Introductory Analysis with Applications to Biology, Control, and Artificial Intelligence.* Cambridge:MIT Press.
HOLLAND, J.H. (1995), *Hidden Order. How Adaptation Builds Complexity.* Reading:Addison-Wesley.
HOLLAND, J.H., K.J. HOLYOAK, R.E. NISBETT, P.R. THAGARD (1989), *Induction. Processes of Inference, Learning, and Discovery.* The MIT Press.
HUBER, J. (1991)(ed.), *Macro-Micro Linkages in Sociology.* Newbury Park:Sage Publications.
HULL, D.L. (1988), *Science as a Process. An Evolutionary Account of the Social and Conceptual Development of Science.* Chicago:The University of Chicago Press.
HUMPHREY, N. (1995), *Die Naturgeschichte des Ich.* Hamburg:Hoffmann und Campe.
IFRAH, G. (1989), *Universalgeschichte der Zahlen.* Frankfurt:Campus-Verlag.
JANIK, A., "Work, Technology, Language: The Role of 'Tacit Knowledge' in Experimental Physics", in: U. FELT, H. NOWOTNY (1995)(eds.), *Social Studies*, op.cit., 135 - 142.
JANTSCH, E. (1972), *Technological Planing and Social Futures.* London:Francis Pinter.
JANTSCH, E. (1982), *Die Selbstorganisation des Universums. Vom Urknall zum menschlichen Geist.* München:DTV.
JASANOFF, S. (1990), *The Fifth Branch. Science Advisers as Policy Makers.* Cambridge:Harvard University Press.
JONES, S. (1993), *The Language of Genes. Solving the Mysteries of Our Genetic Past, Present and Future.* New York:Anchor Books.
JONES, S., R. MARTIN, D. PILBEAM (³1995)(eds.), *The Cambridge Encyclopedia of Human Evolution.* Cambridge:Cambridge University Press.
KAELBLING, L.P. (1993), *Learning in Embedded Systems.* Cambridge: The MIT Press.
KAGEL, J.H., A.E. ROTH (1995)(eds.), *The Handbook of Experimental Economics.* Princeton:Princeton University Press.
KAHNEMANN, D., A. TVERSKY (1973), "On the Psychology of Prediction", in: *Psychological Review* 80, 237:251.
KAHNEMANN, D., P. SLOVIC, A. TVERSKY (1982), *Judgement under Uncertainty: Heuristics and Biases.* Cambridge:Cambridge University Press.
KAUFFMAN, S.A. (1990), "Requirements for Evolvability in Complex Systems", in: W.H. ZUREK (1990), 151 - 192.
KAUFFMAN, S.A. (1993), *The Origins of Order. Self-Organization and Selection in Evolution.* Oxford University Press.
KAUFFMAN, S.A. (1995), *At Home in the Universe. The Search for the Laws of Self-Organization and Complexity.* New York:Oxford University Press.
KAYE, B. (1993), *Chaos and Complexity. Discovering the Surprising Patterns of Science and Technology.* Weinheim:VCH Verlagsgesellschaft.
KINDLEBERGER, C. P.,B.HERRICK (³1981), *Economic Development.* Auckland:McGraw Hill.
KINGDON, J. (1993), *Self-made Man. Human Evolution from Eden to Extinction.* New York:John Wiley&Sons.
KITCHER, P. (1993), *The Advancement of Science. Science without Legend, Objectivity without Illusions.* New York:Oxford University Press.
KLEINKNECHT, A. (1987), *Innovation Patterns in Crisis and Prosperity. Schumpeter's Long Cycle Reconsidered.* London:Macmillan Press.
KNIGHT, R., K. LEITNER (1993), *The Potentials of Vienna's Knowledge Base for City Development.* Vienna:Magistratsabteilung 18.
KNORR-CETINA, K. (1984), *Die Fabrikation von Erkenntnis. Zur Anthropologie der Naturwissenschaft.* Frankfurt:Suhrkamp.
KNORR-CETINA, K. (1988), *The Micro-Social Order. Towards a Reconception*, in: N.G. FIELDING (1988)(ed.), *Actions and Structure. Research Methods and Social Theory.* London:Frances Pinter, 20 - 53.
KNORR-CETINA, K. (1995), "What Scientists Do", in: U. FELT, H. NOWOTNY (1995)(eds.), *Social Studies* op.cit., 117 -133.
KNORR-CETINA, K. (1996), *Epistemic Cultures. How Scientists Make Sense.* (to be published).
KOCH, W.A. (1986), *Genes vs. Memes. Modes of Integration for Natural and Cultural Evolution in a Holistic Model ('ELPIS').* Bochum:Studienverlag Dr. Norbert Brockmeyer.
KOCKELMANS, J. (1978) (ed.), *Interdisciplinarity. Reflections on Historical, Epistemological, Educational and Administrative Issues.* University of Pennsylvania Press.
KOHONEN, T. (1995), *Self-Organizing Maps.* Berlln:Springer.
KOSSLYN, S.M., R.A. ANDERSEN (1992)(eds.), *Frontiers in Cognitive Neuroscience.* Cambridge:The MIT Press.
KOZA, J.R. (1992), *Genetic Programming. On the Programming of Computers by Means of Natural Selection.* Cambridge:The MIT Press.
KREIBICH, R. (1986), *Die Wissenschaftsgesellschaft. Von Galilei zur High-Tech-Revolution.* Frankfurt:Suhrkamp.
KRIPKE, S.A. (1985), *Wittgenstein on Rules and Private Language. An Elementary Exposition.* Oxford:Oxford University Press.
KROHN, E., G. KÜPPERS, H. NOWOTNY (1990)(eds.), *Selforganization. Portrait of a Scientific Revolution.* Dordrecht:Kluwer..
KROHN, W., G. KRÜCKEN (1993)(eds.), *Riskante Technologien: Reflexion und Regulation. Einführung in die sozialwissenschaftliche Risikoforschung.* Frankfurt:Suhrkamp.
KUHN, T.S. (1973), *Die Struktur wissenschaftlicher Revolutionen.* Frankfurt:Suhrkamp.
KÜHNE, K. (1982), *Evolutionsökonomie. Grundlagen der Nationalökonomie und Realtheorie der Geldwirtschaft.* Stuttgart:Gustav Fischer Verlag.

KÜPPERS, B.O. (1987)(eds.), *Ordnung aus dem Chaos. Prinzipien der Selbstorganisation und Evolution des Lebens.* München:Piper.

KURZWEIL, R. ([2]1992), *The Age of Intelligent Machines.* Cambridge:MIT Press.

LANDES, D.S. ([8]1979), *The Unbound Prometheus. Technological Change and Industrial Development in Western Europe from 1750 to the Present.* Cambridge University Press.

LANGLEY, P., H. A. SIMON, G.L. BRADSHAW, J. M. ZYTKOW (1987), *Scientific Discovery. Computational Explorations of the Creative Processes.* Cambridge:The MIT Press.

LANGLOIS, R.N. (1989)(ed.), *Economics as a Process. Essays in the New Institutional Economics.* Cambridge:Cambridge University Press.

LANGTON, C.G. (1989)(ed.), *Artificial Life.* Redwood:Addison Wesley.

LANGTON, C.G. (1994)(ed.), *Artificial Life III.* Redwood:Addison Wesley.

LANGTON, C.G., C. TAYLOR, J.D. FARMER, S. RASMUSSEN (1992)(eds.), *Artificial Life II.* Redwood:Addison Wesley.

LASH, S., B. SZERSZYNSKI, B. WYNNE (1996)(eds.), *Risk, Environment and Modernity. Towards a New Ecology.* London:Sage Publications.

LASZLO (1972), *The Systems View of the World. The Natural Philosophy of the New Developments in the Sciences.* New York:Free Press.

LATOUR, B. (1987), *Science in Action: How to Follow Scientists and Engineers through Society.* Cambridge:Harvard University Press.

LATOUR, B. (1988), *The Pasteurization of France.* Cambridge:Harvard University Press.

LATOUR, B. (1992a), *We Have Never Been Modern.* Cambridge:Harvard University Press.

LATOUR, B., P. MAUGUIN, G. TEIL (1992), "A Note on Socio-Technical Graphs", in: *Social Studies of Science* 22, 33 - 57.

LAUDAN, L. (1977), *Progress and Its Problems. Toward a Theory of Scientific Growth.* Berkely:University of California Press.

LAUDAN, L. (1981), *Science and Hypothesis. Historical Essays on Scientific Methodology.* Dordrecht:Reidel Publishing Company.

LEAKY, R., R. LEWIN (1995), *The Sixth Extinction. Patterns of Life and the Future of Humankind.* New York:Doubleday.

LEM, S. (1983), *Philosophie des Zufalls. Zu einer empirischen Theorie der Literatur.*, 2 vol. Frankfurt am Main:Insel Verlag.

LEYDESDORFF, L., P.v.d. BESSELAAR (1994)(eds.), *Evolutionary Economics and Chaos Theory. New Directions in Technology Studies.* London:Pinter Publishers.

LIGHTFOOT, D. (1991), *How to Set Parameters. Arguments from Language Change.* Cambridge:The MIT Pres.

LIGHTFOOT, D. ([4]1986), *The Language Lottery: Toward a Biology of Grammars.* Cambridge:The MIT Press.

LINDBLOM, C. (1977), *Politics and Markets.* New York:Basic Books.

LINDBLOM, C. (1990), *Inquiry and Change. The Troubled Attempt to Understand and Shape Society.* New Haven:Yale Universioty Press.

LITTLER, D. (1988), *Technological Development.* Oxford:Basil Blackwell.

LLOYD, E.A. (1994), *The Structure and Confirmation of Evolutionary Theory.* Princeton:Princeton University Press.

LOPREATO, J., T. CRIPPEN (n.d.), *Sociology against Darwin: The Will to Perish.* Unpublished manuscript under review by publishers.

LOPREATO, J. (1984), *Human Nature and Biocultural Evolution.* Boston:Allen and Unwin.

LORENZ, K. (1973), *Die Rückseite des Spiegels. Versuch einer Naturgeschichte menschlichen Erkennens.* München:Piper.

LUDWIG, G. ([2]1990), Die Grundstrukturen einer physikalischen Theorie. Berlin:Springer.

LUHMANN, N. (1984), *Soziale Systeme. Grundriß einer allgemeinen Theorie.* Frankfurt:Suhrkamp.

LUHMANN, N. (1988), *Die Wirtschaft der Gesellschaft.* Frankfurt:Suhrkamp.

LUHMANN, N. (1990), *Die Wissenschaft der Gesellschaft.* Frankfurt:Suhrkamp.

LUHMANN, N. (1997), *Die Gesellschaft der Gesellschaft,* 2 vol. Frankfurt:Suhrkamp.

LUMSDEN, C. J., E. 0. WILSON (1981), *Genes, Mind and Culture: The Coevolutionary Process.* Cambridge:Harvard University Press.

LUMSDEN, C.J., E.O. WILSON (1983), *Promethean Fire. Reflections on the Origin of Mind.* Cambridge:Harvard University Press.

LUNDVALL, B.A. (ed.) (1992), *National Systems of Innovation - Towards a Theory of Innovation and Interactive Learning.*London:Pinter.

LUTZ, B. (1984), *Der kurze Traum immerwährender Prosperität. Eine Neuinterpretation der industriell-kapitalistischen Entwicklung im Europa des 20.Jahrhunderts.* Frankfurt:Campus-Verlag.

LYOTARD, J.F. (1982), *Das postmoderne Wissen. Ein Bericht.* Wien:Theatrum Machinarum.

MAASEN, S., E. MENDELSOHN, P. WEINGART (1995)(eds.), *Biology as Society, Society as Biology: Metaphors.* Dordrecht:Kluwer Academic Publishers.

MAASEN, S., P. WEINGART (1995), "Metaphors – Messengers of Meaning. A Contribution to an Evolutionary Sociology of Science", in: *Science Communication* 1, 9–31.

MALIK, F. (1993), *Systemisches Management, Evolution, Selbstorganisation. Grundprobleme, Funktionsmechanismen und Lösungsansätze für komplexe Systeme.* Bern:Verlag Paul Haupt.

MANDELBROT, B.B. ([3]1983), *The Fractal Geometry of Nature.* New York.

MARCHETTI, C. (1981), *Society as a Learning System: Discovery, Invention, and Innovation Cycles Revisited.* Laxenburg 1981.

MARR, D. (1981), *Vision. A Computational Investigation into the Human Representation and Processing of Visual Information.* New York:W.H. Freeman.

MARTINDALE, C. (1990), *The Clockwork Muse. The Predictability of Artistic Change.* New York:Basic Books.

MARYANSKI, A. (1994), "The Pursuit of Human Nature in Sociobiology and Evolutionary Sociology." *Sociological Perspectives* 37, 375-90.

MATJAN, G. (1998), *Auseinandersetzung mit der Vielfalt. Politische Kultur und Lebensstile in pluralistischen Gesellschaften.* Frankfurt:Campus.

MATURANA, H.R. (1985), *Erkennen: Die Organisation und Verkörperung von Wirklichkeit. Ausgewählte Arbeiten zur biologischen Epistemologie.* Braunschweig:Vieweg.

MATURANA, H.R., F.J. VARELA (1987), *Der Baum der Erkenntnis. Die biologischen Wurzeln des menschlichen Erkennens.* Bern:Scherz-Verlag.

MAYNARD SMITH, J. (1974), *Models in Ecology.* Cambridge:Cambridge University Press.

MAYNARD SMITH, J. (1982)(ed.), *Evolution Now. A Century after Darwin.* London:Macmillan.

MAYNARD SMITH, J. (1989), *Evolutionary Genetics*. Oxford:Oxford University Press.
MAYNARD SMITH, J. (³1985), *Evolution and the Theory of Games*. Cambridge:Cambridge University Press.
MAYNTZ, R., F.W. SCHARPF (1995)(eds.), *Gesellschaftliche Selbstregelung und politische Steuerung*. Frankfurt:Campus Verlag.
MAYNTZ, R., T.P. HUGHES (1988)(eds.), *The Development of Large Technical Systems*. Frankfurt:Campus.
McCULLOCH, W.S. (1988), *Embodiments of Mind*. Cambridge:The MIT Press.
McPHERSON, J. M., J. RANGER-MOORE (1991), "Evolution on a Dancing Landscape: Organizations and Networks in Dynamic Blau-space" *Social Forces* 70:19-42.
MENSCH, G. (1977), *Das technologische Patt. Innovationen überwinden die Depression.* Frankfurt am Main:Fischer.
MENSCH, G., W. WEIDLICH, G. HAAG (1991), "The Schumpeter Clock. A Micro-Macro-Model of Economic Change, Including Innovation, Strategic Investment, Dynamic Competition and Short and Long Swings in Industrial Transformation - Applied to United States and German Data, in: OECD (1991)(ed.), *Technology and Productivity. The Challenge for Economic Policy*. Paris:OECD.
MERTON, R.K. (1985), *Entwicklung und Wandel von Forschungsinteressen. Aufsätze zur Wissenschaftssoziologie*. Frankfurt:Suhrkamp.
MICHALSKI, R.S., J.G. CARBONELL, T.M. MITCHELL (1986)(eds.), *Machine Learning. An Artificial Intelligence Approach*. Los Altos:Morgan Kaufmann.
MILLER, J. (1978), *Living Systems*. New York:Basic Books.
MILLIKAN, R.G. (1984), *Language, Thought, and Other Biological Categories. New Foundations for Realism. Cambridge*: Cambridge:The MIT Press.
MINSKY, M. (1990), *Mentopolis*. Stuttgart:Klett-Cotta.
MORTON, E.S., J. PAGE (1992), *Animal Talk. Science and the Voices of Nature*. New York:Random House.
MUELLER, D.C. (1983)(ed.), *The Political Economy of Growth*. New Haven:Yale University Press.
MÜLLER, K.H. (1988), "Weltwirtschaft und nationale Wissenschaftsentwicklung. Ein Erklärungssketch", in: F. STADLER (ed.), *Kontinuität und Bruch 1938 – 945 – 1955. Beiträge zur österreichischen Kultur- und Wissenschaftsgeschichte*. Wien:Jugend und Volk, 341 – 399.
MÜLLER, A., K.H. MÜLLER, F. STADLER (1997)(eds.), *Konstruktivismus und Kognitionswissenschaft. Kulturelle Wurzeln und Ergebnisse. Heinz von Foerster gewidmet*. Wien-New York:Springer-Verlag.
MÜLLER, K.H. (1995a), "Zement und Gesellschaft. Modernisierungsskizzen aus dem Geist Karl Polanyis", in: K. R. LEUBE, A. PRIBERSKI (1995)(eds.), *Krise und Exodus. Österreichische Sozialwissenschaften in Mitteleuropa*. Wien:WUV-Universitätsverlag, 146 - 190
MÜLLER, K.H. (1995b), *Epistemic Cultures in the Social Sciences. The Modeling Dilemma Dissolved*. Vienna:IHS Research Paper.
MÜLLER, K.H. (1996a), *The Basic Architecture of Contemporary Knowledge and Information Societies. Theory, History, Measurement, Complex Modeling, Policy*. Habilitationsschrift for the University of Bielefeld.
MÜLLER, K.H. (1996d), "Sozialwissenschaftliche Kreativität in der Ersten und in der Zweiten Republik", in: *Österreichische Zeitschrift für Geschichtswissenschaften* 1, 9 - 43.
MÜLLER, K.H. (1997a), *Sozio-ökonomische Modellbildung und gesellschaftliche Komplexität. Vermittluing & Designs*. Marburg:Metropolis-Verlag.
MÜLLER, K.H. (1997d), "Die Konstruktion komplexer historischer Modelle. Second-Order-Explorationen", in: *Österreichische Zeitschrift für Geschichtswissenschaft* 1, 77 - 100.
MÜLLER, K.H. , L. LASSNIGG (1992)(eds.), *Langfristige Szenarienanalyse des österreichischen Bildungssystems*. Vienna:IHS.
MÜLLER, K.H., G. HAAG (1994)(eds.), *Komplexe Modelle in den Sozialwissenschaften*. Special Edition of WISDOM 3/4.
MÜLLER, K.H., K. PICHELMANN (1990)(eds.), *Modell zur Analyse des österreichischen Beschäftigungssystems*. Vienna:IHS.
MÜLLER, K.H., T. LINK (1997), *Lebensformen und Risikogruppen in Wien. Soziale Konstellationen für Gesundheit, Beschwerden und Krankheiten in einem urbanen Raum*. Wien:IHS.
NADEL, L., D.L. STEIN (1991)(eds.), *1990 Lectures in Complex Systems*. Redwood City:Addison-Wesley.
NAISBITT, J. (1982), *Megatrends. 10 Perspektiven, die unser Leben verändern werden*. München:Piper.
NEFIODOW, L.A. (²1991), *Der fünfte Kondratieff. Strategien zum Strukturwandel in Wirtschaft und Gesellschaft*. Wiesbaden:Gabler-Verlag.
NEGROPONTE, N. (1996), *Being Digital*. New York:Vintage Books.
NELSON, R. R. (1993)(ed.), *National Innovation Systems: A Comparative Analysis*. New York:Oxford University Press.
NELSON, R.J. (1982), *The Logic of Mind*. Dordrecht:Reidel..
NELSON, R.R., S.G. WINTER (1982), *An Evolutionary Theory of Economic Change*. Cambridge:Harvard University Press.
NEURATH, O. (1981), *Gesammelte philosophische und methodologische Schriften*.(ed. by R. Haller and H. Rutte). Vienna:Hölder Pichler Tempsky.
NEWELL, A. (1990), *Unified Theories of Cognition*. Harvard University Press.
NICOLIS, G., I. PRIGOGINE (1977), *Self-Organization in Nonequilibrium Systems. From Dissipative Structures to Order through Fluctuations*. New York:John Wiley&Sons.
NICOLIS, G., I. PRIGOGINE (³1982), *Vom Sein zum Werden. Zeit und Komplexität in den Naturwissenschaften*. München:Piper.
NOWOTNY, H. (1995), *The Dynamics of Innovation. On the Multiplicity of the New*. Budapest:Collegium Hungaricum.
NUSSBAUM, M.C., A. SEN (1993)(eds.), *The Quality of Life*. Oxford:Clarendon Press.
OECD (1994a), *Interaction in Knowledge Systems. Foundation, Policy Implications and Empirical Methods*. DSTI/STP/TIP(94)15. Paris:OECD.
OECD (1994b), *The Measurement of Scientific and Technical Activities*. (Frascati Manual 1993) Paris:OECD.
OECD (1994c), *National Innovation Systems. Work Plan for Pilot Case Studies*. DSTI/STP/TIP(94)16/REV1.Paris:OECD.
OECD (1994d), *Technology Flows in National Systems of Innovation*. DSTI/STP/TIP(94)3. Paris:OECD.
OLSON, M. (1982), *The Rise and Decline of Nations. Economic Growth, Stagflation and Social Rigidities*. Yale:Yale University Press.
PAHL, R. (1995), *After Success. Fin de Siècle Anxiety and Identity*. Cambridge:Polity Press.
PARSONS, T. (1964), "Evolutionary Universals in Society", in: *American Sociological Review* 19, 339 - 357.

PARSONS, T. (1994), *Aktor, Situation und normative Muster. Ein Essay zur Theorie sozialen Handelns.* Frankfurt:Suhrkamp.

PASLACK, R. (1991), *Urgeschichte der Selbstorganisation. Zur Archäologie eines wissenschaftlichen Paradigmas.* Braunschweig-Wiesbaden.

PAVITT, K.L.R. (1991), "What Makes Basic Research Economically Useful", in: *Research Policy* 20, 109 - 119.

PAVITT, K:L.R. (1987), "The Objectives of Technology Policy", in: *Science and Public Policy* 14, 182 - 188.

PEAK, D., M. FRAME (1995), *Komplexität - das gezähmte Chaos.* Basel:Birkhäuser Verlag.

PENROSE, R. (1995), *Shadows of the Mind. A Search for the Missing Science of Consciousness.* London:Vintage.

PERROUX, F. (1983), *A New Concept of Development. Basic Tenets.* Paris:OECD.

PESCHEL, M., W. MENDE (1986), *The Predator-Prey Model. Do We Live in a Volterra World.* Wien:Springer-Verlag.

PESCHL, M.F. (1994), Repräsentation und Konstruktion. Kognitions- und neuroinformatische Konzepte als Grundlage einer naturalisierten Epistemologie und Wissenschaftstheorie. Braunschweig:Vieweg.

PETSCHE, T., S.J. HANSON, J. SHAVLIK (1995)(eds.), *Computational Learning Theory and Natural Learning Systems. Volume III: Selecting Good Models.* Cambridge:The MIT Press.

PIAGET, J. (1973), Einführung in die genetische Erkenntnistheorie. Frankfurt:Suhrkamp.

PIAGET, J. (1983), *Biologie und Erkenntnis. Über die Beziehungen zwischen organischen Regulationen und kognitiven Prozessen.* Frankfurt:Fischer.

PIAGET, J. (1973), *Einführung in die genetische Erkenntnistheorie.* Frankfurt:Suhrkamp.

PIATELLI-PALMARINI, M. (ed.)(1980), *Language and Learning. The Debate between Jean Piaget and Noam Chomsky.* London:Routledge & Kegan Paul.

PICKERING, A. (1992)(ed.), *Science as Practice and Culture.* Chicago:The University of Chicago Press.

PINES, D. (1988)(ed.), *Emerging Syntheses in Science.* Redwood City:Addison Wesley.

PINKER, S. (1994), *The Language Instinct.* New York:William Morrow and Company.

PLOTKIN, H. (1994), *Darwin Machines and the Nature of Knowledge.* Cambridge:Harvard University Press.

POLANYI, K. (1978), *The Great Transformation. Politische und ökonomische Ursprünge von Gesellschaften und Wirtschaftssystemen.* Frankfurt:Suhrkamp.

POLANYI, K. (1979), *Ökonomie und Gesellschaft.* Frankfurt:Suhrkamp.

POLANYI, M. (1985), *Implizites Wissen.* Frankfurt:Suhrkamp.

POLLARD, S. (1981), *Peaceful Conquest. The Industrialization of Europe 1760 - 1970.* Oxford:Oxford University Press.

POLLOCK, J.S. (1989), *How to Build a Person: A Prolegomenon.* Cambridge:The MIT Press

POLT, W. (1993), *Information Technology Diffusion Policies for Small- and Medium-Sized Enterprises.* Background Report. Seibersdorf:Forschungszentrum Seibersdorf.

POPCORN, F., L. MARIGOLD (1996), *'Clicking'. Der neue Popcorn Report. Trends für unsere Zukunft.* München:Wilhelm Heyne Verlag.

POPPER, K.R (1965), *Conjectures and Refutations. The Growth of Scientific Knowledge.* New York:Harper&Row.

POPPER, K.R. (1982b), *The Open Universe. An Argument for Indeterminism. From the 'Postscript to the Logic of Scientific Discovery'.* Totowa:Rowman and Littlefield.

POPPER, K.R. ([3]1975), *Objective Knowledge. An Evolutionary Approach.* Oxford:Oxford University Press.

POPPER, K.R.([3]1971), *Das Elend des Historizismus.* Tübingen:J.C.B. Mohr.

POPPER, K.R., J.C. ECCLES (1982), *Das Ich und sein Gehirn.* München:Piper.

POPPER, K.R.. (1982a), *Quantum Theory and the Schism in Physics. From the 'Postscript to the Logic of Scientific Discovery'.* London:Totowa Press.

PORTER, M.E. (1985), *Competitive Advantage. Creating and Sustaining Superior Performance.* New York:The Fre Press.

PORTER, M.E. (1990), *The Competitive Advantage of Nations.* New York:The Free Press.

POSNER, M.I. (1989)(ed.), *Foundations of Cognitive Science.* Cmbridge:The MIT Press.

PRIGOGINE, I., I. STENGERS (1984), *Order out of Chaos. Man's New Dialogue with Nature.* Toronto et al.

PRIGOGINE, I., I. STENGERS (1993), *Das Paradox der Zeit. Zeit, Chaos und Quanten.* München-Zürich.

QUINN, J. (1992), *Intelligent Enterprise.A Knowledge and Service Based Paradigm for Industry.* New York:Free Press.

RAYNAL, G., D. DIDEROT (1988); *Die Geschichten beider Indien.* Nördlingen:Franz Greno.

RESCHER, N. (1982), *Wissenschaftlicher Fortschritt. Eine Studie über die Ökonomie der Forschung.* Berlin:de Gruyter.

RIEDL, R. (1975), *Die Ordnung des Lebendigen. Systembedingungen der Evolution.* Hamburg:Paul Parey.

RIEDL, R. ([2]1980), *Strategie der Genesis. Naturgeschichte der realen Welt.* München:Piper.

RITTER, H., T. MARTINEZ, K. SCHULTEN ([2]1991), *Neuronale Netze. Eine Einführung in die Neuroinformatik selbstorganisierender Netzwerke.* Bonn:Addison-Wesley.

RITZER, G. (1993), *The McDonaldization of Society. An Investigation Into the Changing Character of Contemporary Social Life.* Thousand Oaks:Pine Forge Press.

RITZER, G. ([2]1988), *Contemporary Social Theory.* New York:Basic Books.

ROJAS, R. (1993), *Theorie der neuronalen Netze. Eine systematische Einführung.* Berlin:Springer.

ROOT BERNSTEIN, R.S. (1989), *Discovering. Inventing and Solving Problems at the Frontiers of Scientific Knowledge.* Cambridge:Harvard University Press.

ROSE, S. (1997), *Lifelines.* Harmondsworth:Penguin.

ROSEN, M.R. (1991), *Life Itself.* New York:Columbia University Press.

ROSENBERG, N. (1982), *Inside the Black Box: Technology in Economics.* New York:Cambridge University Press.

ROSENBERG, N., R. LANDAU, D.C. MOWERY (1992)(eds.), *Technology and the Wealth of Nations.* Stanford:Stanford University Press.

ROSTOW, W.W. (1978), *The World Economy. History & Prospect.* Austin:University of Texas Press.

ROSTOW, W.W. ([2]1971), *The Stages of Economic Growth. A Non-Communist Manifesto.* Cambridge:Cambridge University Press.

ROTH, G., H. SCHWEGLER (1981)(eds.), *Self-Organizing Systems. An Interdisciplinary Approach.* Frankfurt:Campus.

ROTHWELL, R., W. ZEGVELD (1985), *Reindustrialization and Technology.* Harlow.

ROUSSEL, P.A., K.N. SAAD, T.J. ERICKSON (1991), *Third Generation R&D. Managing the Link to Corporate Strategy.* Boston:Harvard Business School Press.

RUMELHART, D.E., J.L. McCLELLAND (1986), *Parallel Distributed Processing. Explorations in the Microstructure of Cognition,* 2 vol. Cambridge:The MIT Press.

SCHERER, F.M. (1986), *Innovation and Growth. Schumpeterian Perspectives.* Cambridge:MIT Press.

SCHIEBINGER, L. (1995), *Am Busen der Natur.* Stuttgart:Klett-Cotta.
SCHMIDT, S.J. (1987)(ed.), *Der Diskurs des radikalen Konstruktivismus.* Frankfurt:Suhrkamp.
SCHNEIDER, S.H. (1997), *Laboratory Earth. The Planetary Gamble We Can't Afford to Loose.* London:Phoenix.
SCHÖNEBURG, E. (1993)(ed.), *Industrielle Anwendung Neuronaler Netze. Fallbeispiele und Anwendungskonzepte.* Bonn:Addison-Wesley.
SCHUMPETER, J.A. (1961), *Konjunkturzyklen. Eine theoretische, histori-sche und statistische Analyse des kapitalistischen Prozesses,* 2 Bde. Göttingen.
SCHUMPETER, J.A. (1989), *Essays. On Entrepreneurs, Innovations, Business Cycles, and the Evolution of Capitalism.* New Brunswick:Transaction Publishers.
SCHUMPETER, J.A. (⁴1975), *Kapitalismus, Sozialismus und Demokratie.* München:Francke Verlag.
SCHUSTER, P. (1984)(eds.), *Stochastic Phenomena and Chaotic Behaviour in Complex Systems.* Berlin:Springer.
SCITOVSKY, T. (²1992), *The Joyless Economy. The Psychology of Human Satisfaction.* New York:Oxford University Press.
SCOTT-MORGAN, P., A.D. LITTLE (³1995), *Die heimlichen Spielregeln. Die Macht der ungeschriebenen Gesetze im Unternehmen.* Frankfurt:Campus.
SENGE, P. (1990), *The Fifth Discipline: Mastering the Five Practices of the Learning Organisation.* New York: Doubleday.
SERPELL, J. (1986), *In the Company of Animals. A Study of Human-Animal Relationships.* Oxford:Basil Blackwell.
SHAPIN, S., S. SCHAFFER (1985), *Leviathan and the Air-Pump. Hobbes, Boyle and the Experimental Life.* Princeton:Princeton University Press.
SIGMUND, K. (1995), *Games of Life. Explorations in Ecology, Evolution and Behaviour.* Harmondsworth:Penguin.
SILVERS, R.B. (1996)(ed.), *Verborgene Geschichten der Wissenschaft.* Berlin:Berlin-Verlag.
SIMON, H. A. (1993), *Homo rationalis. Die Vernunft im menschlichen Leben.* Frankfurt:Campus Verlag.
SIMON, H.A. (1977), *Models of Discovery and Other Topics in the Methods of Science.* Dordrecht:Reidel.
SKELTON, P. (1993)(ed.), *Evolution. A Biological and Palaeontological Approach.* Wokingham:Addison Wesley Publishing Company.
SOBER, E. (³1986)(ed.), *Conceptual Issues in Evolutionary Biology. An Anthology.* Cambridge:The MIT Press.
SOROS, G. (1994), *The Alchemy of Finance. Reading the Mind of the Market.* New York:John Wiley&Sons.
SPENCER, H. (1874-96), *The Principles of Sociology.* New York:Appleton-Century.
SPRÜNGLI, R.K. (1981), *Evolution und Management. Ansätze zu einer evolutionistischen Betrachtung sozialer Systeme.* Bern-Stuttgart.
STEGMÜLLER, W. (1986), *Kripkes Deutung der Spätphilosophie Wittgensteins. Kommentarversuch über einen versuchten Kommentar.* Stuttgart: Alfred Kröner Verlag.
STEHR, N. (1994), *Arbeit, Eigentum und Wissen. Zur Theorie von Wissensgesellschaften.* Frankfurt am Main:Suhrkamp.
STEIN, D.L. (1989)(ed.), *Lectures in the Sciences of Complexity. The Proceedings of the 1988 Complex Systems Summer School.* Redwood City:Addison Wesley.
STERNBERG, R.J., C.A. BERG (1992)(eds.), *Intellectual Development.* Cambridge:Cambridge University Press.
STERNBERG, R.J., P.A. FRENSCH (1991)(eds.), *Complex Problem Solving: Principles and Mechanisms.* Hillsdale:Lawrence Erlbaum Associates.
STERNBERG, R.J., R. K. WAGNER (1994)(eds.), *Mind in Context. Interactionist Perspectives on Human Intelligence.* Cambridge:Cambridge University Press.
STICHWEH, R. (1991), *Der frühmoderne Staat und die europäische Universität. Zur Interaktion von Politik und Erziehungssystem im Prozeß ihrer Ausdifferenzierung.* Frankfurt:Suhrkamp.
STONEMAN, P. (1983), *The Economic Analysis of Technological Change.* Oxford University Press.
STONIER, T. (1990), *Information and the Internal Structure of the Universe. An Exploration into Information Physics.* London:Springer.
STREIT, B. (1995)(ed.), *Evolution des Menschen.* Heidelberg:Spektrum.
SWAAN, A.d. (1994), *Der sorgende Staat. Wohlfahrt, Gesundheit und Bildung in Europa und den USA der Neuzeit.* Frankfurt:Campus Verlag.
SWEDBERG, R. (1993)(ed.), *Explorations in Economic Sociology.* New York:Russell Sage Foundation.
SWEDBERG, R. (1994), *Joseph A. Schumpeter. Eine Biographie.* Stuttgart:Klett-Cotta.
SWOBODA, W.W. (1978), *Disciplines and Interdisciplinarity. A Historical Perspective,* in: J. KOCKELMANS (1978), 49 - 92.
SZTOMPKA, P. (1991), *Society in Action. The Theory of Social Becoming.* Cambridge:Polity Press.
TAYLOR, F.W. (1971), *The Principles of Scientific Management.* New York:Basic Books.
THAGARD, P. (1988), *Computational Philosophy of Science.* Cambridge:The MIT Press.
THAGARD, P. (1992), *Conceptual Revolutions.* Princeton:Princeton University Press.
THERBORN, G. (1995a), *European Modernity and Beyond. The Trajectory of European Societies 1945 - 2000.* London:Sage Publications.
THOM, R. (1989), *Structural Stability and Morphogenesis. An Outline of a General Theory of Models.* Redwood City:Addison Wesley.
THUROW, L.C. (1996), *The Future of Capitalism. How Today's Economic Forces Shape Tomorrow's World.* New York:William Morrow and Company.
TIRYAKIAN, E. (1991), "Modernization: Exhumetur in Pace. Rethinking Macrosociology in the 19902, in: *International Sociology* 2, 165 - 180.
TODARO M.P. (³1985), *Economic Development in the Third World.* New York:Longman.
TOOBY, J., L. COSMIDES (1989), "Evolutionary Psychology and the Generation of Culture, Part I. Theoretical Considerations." *Ethnology and Sociobiology* 10, 29-49.
TOURAINE, A. (1971), *The Post-Industrial Society. Tomorrow's Social History: Classes, Conflicts and Culture in the Programmed Society.* New York:Basic Books.
TROITZSCH, K.G. (1990), *Modellbildung und Simulation in den Sozialwissenschaften.* Opladen:Westdeutscher Verlag.
TUFILLARO, N.B., T. ABBOTT, J. REILLY (1992), *An Experimental Approach to Nonlinear Dynamics and Chaos.* Redwood City:Addison Wesley.
TURKLE, S. (1995), *Life on the Screen. Identity in the Age of Internet.* New York:Simon&Schuster.
TURNER, J.H. (1987), "Analytical Theorizing", in: A. GIDDENS, J.H. TURNER (1987)(eds.), *Social Theory Today.* Cambridge:Polity Press, 156 - 194.
TURNER, J.H. (1995), *Macrodynamics. Toward a Theory on the Organization of Human Populations.* New Brunswick:Rutgers University Press.

TURNER, J.H., A.R. MARYANSKI (1993), "The Biology of Human Organization", in: *Advances in Human Ecology* 2, 1 - 33.
ULLRICH, O. (1987), *Wege und Abwege der 'Informationsgesellschaft'*, in: *Soziologische Revue* 10, 31 - 43.
ULRICH, H., G.J.B. PROBST (1984)(eds.), *Self-Organization and Management of Social Systems. Promises, Doubts, and Questions.* Berlin :Springer.
UNDP (1995), *Human Development Report 1995.* New York:Oxford University Press.
UTTERBACK, J.M. (1994), *Mastering the Dynamics of Innovation. How Companies Can Seize Opportunities in the Face of Technological Change.* Boston:Harvard Business School Press.
VALLACHER, R.R., A. NOWAK (1994)(eds.), *Dynamical Systems in Social Psychology.* San Diego:Academic Press.
VAN d. BERGHE, P. (1981), *The Ethnic Phenomenon.* New York:Elsevier.
VARELA, F.J. (1979), *Principles of Biological Autonomy.* New York.
VARELA, F.J., E. THOMPSON, E. ROSCH (1991), *The Embodied Mind. Cognitive Science and Human Experience.* Cambridge:MIT Press.
VARELA, F.J., P. BOURGINE (1992)(eds.), *Toward a Practice of Autonomous Systems. Proceedings of the First European Conference on Artificial Life.* Cambridge:The MIT Press.
VEDIN, B.A. (1993), *Information, Technology, Social Fabric.* Stockholm:TELDOK.
VELICHKOVSKY, B.M., D.M. RUMBAUGH (1997)(eds.), *Communicating Meaning. The Evolution and Development of Language.* Mahwoh, N.J:Lawrence Erlbaum Associates.
VOSNIADOU, S., A. ORTONY (1989)(eds.)., *Similarity and Analogical Reasoning.* Cambridge:Cambridge University Press.
WAGNER, P. (1990), *Sozialwissenschaften und Staat. Frankreich, Italien, Deutschland 1870 - 1980.* Frankfurt:Campus Verlag.
WAGNER, P. (1995), *Soziologie der Moderne. Freiheit und Disziplin.* Frankfurt:Campus Verlag.
WALLERSTEIN, I. (1974), *The Modern World System I. Capitalist Agriculture and the Origins of the European World Economy in the Sixteenth Century.* New York:Academic Press.
WALLERSTEIN, I. (1979), *The Capitalist World-Economy.* Cambridge:Cambridge University Press.
WALLERSTEIN, I. (1980), *The Modern World System II. Mercantilism and the Consolidation of the European World Economy.* New York:Academic Press.
WALLERSTEIN, I. (1984), *The Politics of the World Economy. The States, the Movements and the Civilizations.* Cambridge:Cambridge University Press.
WALLERSTEIN, I. (1991), *Unthinking Social Science. The Limits of Nineteenth-Century Paradigms.* Cambridge:Polity Press.
WALLERSTEIN, I. (1995), *After Liberalism.* New York:The New Press.
WARD, P. (1994), *The End of Evolution. On Mass Extinctions and the Preservation of Biodiversity.* New York:Bantam Books.
WARE, A. (1989), *Between Profit and State. Intermediate Organizations in Britain and the United States.* Cambridge:Cambridge University Press.
WATERS, M. (1994), *Modern Sociological Theory.* London:Sage.
WATERSON, M. (1984), *Economic Theory of the Industry.* Cambridge:Cambridge University Press.
WEBSTER (1993), *Webster's New Encyclopedic Dictionary.* Köln:Könemann.
WEIDLICH, W., G. HAAG (1983), *Concepts and Models of a Quantitative Sociology. The Dynamics of Interacting Populations.* Berlin:Springer.
WEIDLICH, W., G. HAAG (1988)(eds.), *Interregional Migration. Dynamic Theory and Comparative Analysis.* Berlin:Springer.
WEINGART, P., P.J. RICHERSON, S.D. MITCHELL, S. MAASEN (1997)(eds.), *Human by Nature. Between Biology and the Social Sciences.* Mahwoh, N.J:Lawrence Erlbaum Associates.
WEINGART, P., R. SEHRINGER, R., J. STRATE, M. WINTERHAGER (1989), *Der Stand der schweizerischen Grundlagenforschung im internationalen Vergleich. Wissenschaftsinsikatoren auf der Grundlage bibliometrischer Daten.* Bern:Schweizer Nationalfond zur Förderung der wissenschaftlichen Forschung.
WEINGARTNER, P., G. DORN (1986)(eds.), *Foundations of Physics.* Vienna:Verlag Hölder-Pichler-Tempsky.
WEINTRAUB, S. (1977)(ed.), *Modern Economic Thought.* University of Pennsylvania Press.
WEST, T.G. (1991), *In the Mind's Eye. Visual Thinkers, Gifted People with Learning Difficulties, Computer Images, and the Ironies of Creativity.* Buffalo:Prometheus Books.
WIESER, W. (1994)(ed.), *Die Evolution der Evolutionstheorie. Von Darwin zur DNA.* Heidelberg:Spektrum Akademischer Verlag.
WILLIAMS, G.C. (1997), *Plan & Purpose in Nature.* London:Phoenix.
WILLIAMSON, O. (1975), *Markets and Hierarchies. Analysis and Antitrust Implications.* New York:Free Press.
WILLIAMSON, O. (1985), *The Economic Institutions of Capitalism. Firms, Markets, Relational Contracting.* New York:Free Press.
WILLIAMSON, O., S. WINTER (1991)(eds.), *The Nature of the Firm. Origins, Evolution and Development.* New York:Oxford University Press.
WILLIS, C. (1993), *The Runaway Brain. The Evolution of Human Consciousness.* New York:Basic Books.
WILLKE, H. (^{2}1993), *Systemtheorie entwickelter Gesellschaften. Dynamik und Riskanz moderner gesellschaftlicher Selbstorganisation.* Weinheim:Jubventa Verlag.
WILLKE, H. (1995), *Systemtheorie III: Steuerungstheorie. Grundzüge einer Theorie der Steuerung komplexer Sozialsysteme.* Stuttgart:Gustav Fischer Verlag.
WILLKE, H. (^{2}1996), *Systemtheorie II. Interventionstheorie. Grundzüge einer Theorie der Intervention in komplexe Systeme.* Stuttgart:Lucius&Lucius.
WILLKE, H. (1997), *Supervision des Staates.* Frankfurt:Suhrkamp.
WILSON, E.O. (1994), *The Diversity of Life.* Harmondsworth:Penguin.
WILSON, E. 0. (1978), *Sociobiology: The New Synthesis.* Cambridge:Harvard University Press.
WINOGRAD, T. (1983), *Language as a Cognitive Process, Vol. 1: Syntax.* Reading:Addison-Wesley.
WITT, U. (1993)(ed.), *Evolutionary Economics.* Aldershot:Elgar Reference Collection.
WITTGENSTEIN, L. (1971a), *Philosophische Untersuchungen.* Frankfurt:Suhrkamp.
WITTGENSTEIN, L. (1971b), *Über Gewißheit.* Frankfurt:Suhrkamp.
WITTGENSTEIN, L. (1984), *Bemerkungen über die Grundlagen der Mathematik.* Frankfurt:Suhrkamp.
WITTROCK, B. (1993), "The Modern University: the Three Transformations", in: S. ROTHBLATT, B. WITTROCK (1993)(eds.), *The European and the American University since 1800. Historical and Sociological Essays.* Cambridge:Cambridge University Press, 303 - 362.
YOUNG, P. (1987), *The Nature of Information.* New York:Praeger.

ZAPF, W. (1994), *Modernisierung, Wohlfahrtsentwicklung und Transformation. Soziologische Aufsätze 1987 bis 1994*. Berlin:edition Sigma.
ZAPF, W. (^{3}1971)(ed.), *Theorien des sozialen Wandels*. Köln:Kiepenheuer&Witsch.
ZELENY, M., (1981)(ed.), *Autopoiesis. A Theory of Living Organization*. New York:Oxford University Press.
ZELL, A. (1994), *Simulation Neuronaler Netze*. Bonn:Addison Wesley.
ZHANG, W.B. (1991), *Synergetic Economics. Time and Change in Nonlinear Economics*. Berlin:Springer.
ZIMAN, J. (1995), *Of One Mind: The Collectivization of Science*. Woodbury:American Institute of Physics Press.
ZUREK, W.H. (ed.)(1990), *Complexity, Entropy, and the Physics of Information*. Redwood City:Addison Wesley.

Institut für Höhere Studien
Institute for Advanced Studies
Stumpergasse 56
A-1060 Vienna
Austria

Phone: +43-1-599 91-216
Fax: +43-1-599 91-191